State of New York—Department of Agriculture.

Twentieth Annual Report

OF THE

BOARD OF CONTROL

OF THE

NEW YORK

Agricultural Experiment Station

(GENEVA, ONTARIO COUNTY).

For the Year 1901.

With Reports of Director and Other Officers.

TRANSMITTED TO THE LEGISLATURE JANUARY 13, 1902.

ALBANY
J. B. LYON COMPANY, STATE PRINTERS
1902

STATE OF NEW YORK.

No. 59.

IN ASSEMBLY,

JANUARY 13, 1902.

TWENTIETH ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station.

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, *January* 13, 1902.

To the Assembly of the State of New York:

I have the honor to herewith submit the Twentieth Annual Report of the Director and Board of Managers of the New York Agricultural Experiment Station at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

CHARLES A. WIETING,

Commissioner of Agriculture.

1901.

ORGANIZATION OF THE STATION.

BOARD OF CONTROL.

GOVERNOR BENJAMIN B. ODELL, JR., Albany.
STEPHEN H. HAMMOND, Geneva.
AUSTIN C. CHASE, Syracuse.
FRANK O. CHAMBERLAIN, Canandaigna.
FREDERICK C. SCHRAUB, Lowville.
NICHOLAS HALLOCK, Queens.
LYMAN P. HAVILAND, Camden.
EDGAR G. DUSENBURY, Portville.
OSCAR H. HALE, North Stockholm.
MARTIN L. ALLEN, Fayette.

OFFICERS OF THE BOARD.

STEPHEN H. HAMMOND, *President.*

WILLIAM O'HANLON, *Secretary and Treasurer.*

EXECUTIVE COMMITTEE.

STEPHEN H. HAMMOND,
MARTIN L. ALLEN,
FRANK O. CHAMBERLAIN,
FREDERICK C. SCHRAUB,
LYMAN P. HAVILAND,
NICHOLAS HALLOCK.

STATION STAFF.

WHITMAN H. JORDAN, SC. D., *Director.*

GEORGE W. CHURCHILL, *Agriculturist and Superintendent of Labor.*
WILLIAM P. WHEELER, *First Assistant (Animal Industry).*
FRED C. STEWART, M. S., *Botanist.*
HARRY J. EUSTACE, B. S., *Student Assistant in Botany.*
LUCIUS L. VANSLYKE, PH.D., *Chemist.*
CHRISTIAN G. JENTER, PH.C.,
*WILLIAM H. ANDREWS, B.S.,
¶J. ARTHUR LECLERC, B.S.,
FREDERICK D. FULLER, B.S.,
EDWIN B. HART, B.S.,
*CHARLES W. MUDGE, B.S.,
ANDREW J. PATTEN, B.S., *Assistant Chemists.*
HARRY A. HARDING, M.S., *Dairy Bacteriologist.*
LORE A. ROGERS, B.S, *Assistant Bacteriologist.*
GEORGE A. SMITH, *Dairy Expert.*
FRANK H. HALL, B.S., *Editor and Librarian.*
VICTOR H. LOWE, M.S.,
†F. ATWOOD SIRRINE, M.S., *Entomologists.*
PERCIVAL J. PARROTT, A.M., *Assistant Entomologist.*
SPENCER A. BEACH, M.S., *Horticulturist.*
NATHANIEL O. BOOTH, B.AGR., *Assistant Horticulturist.*
ORRIN M. TAYLOR, *Foreman in Horticulture*
FRANK E. NEWTON,
JENNIE TERWILLIGER, *Clerks and Stenographers.*
ADIN H. HORTON, *Computer.*

Address all correspondence, not to individual members of the staff, but to the NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

---

*Connected with Fertilizer Control.
†At Second Judicial Department Branch Station, Jamaica, N. Y.
¶Absent on leave.

TABLE OF CONTENTS.

TWENTIETH ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station.

TREASURER'S REPORT.

GENEVA, N. Y., *October* 1, 1901.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending September 30, 1901:

GENERAL EXPENSE, APPROPRIATION 1900–1901.

Receipts.

1900.				
Oct.	1.	To balance on hand....................		$2,742 26
		To amount received from Comptroller	$18,750 00	
		Less balance due appropriation 1899-1900.......	3,750 00	
				15,000 00
				$17,742 26

Expenditures.

1900.				
Oct.	1.	By building and repairs		$780 57
		By chemical supplies		230 34
		By contingent expenses		804 45
		By feeding stuffs		1,817 86
		By fertilizers		84 29
		By freight and express		478 65
		By furniture and fixtures		1,094 63
		By heat, light and water		2,033 45
		By library		668 50
		By live stock		8 75
		By postage and stationery		884 91
		By publications		1,954 90
		By scientific apparatus		151 50
		By seeds, plants and sundry supplies		1,673 15
		By tools, implements and machinery		406 13
		By traveling expenses		958 61
				$14,030 69
		By balance, October 1, 1901		3,711 57
				$17,742 26

SALARIES, APPROPRIATION 1900–1901.

Receipts.

1900.				
Oct.	1.	To balance		$5,648 66
		To amount received from Comptroller	$28,750 00	
		Less balance due appropriation 1899-1900	5,750 00	
				23,000 00
				$28,648 66

Expenditures.

1901.			
Oct. 1.	By salaries		$21,860 07
	By balance		6,788 59
			$28,648 66

LABOR.

Receipts.

1900.			
Oct. 1.	To balance		$2,975 71
	To amount received from Comptroller	$15,000 00	
	Less balance due appropriation 1899-1900	3,000 00	
			12,000 00
			$14,975 71

Expenditures.

1901.			
Oct. 1.	By labor		$11,728 90
	By balance		3,246 81
			$14,975 71

EXPENSE OF BULLETINS AND ENFORCING PROVISIONS OF CHAPTER 955, LAWS OF 1896.—APPROPRIATION 1898-1899.

Receipts.

1900.		
Oct. 1.	To balance on hand	$6 20

Expenditures.

	By postage and stationery	$6 20

COMMERCIAL FERTILIZERS, APPROPRIATION 1900–1901.

Receipts.

1900.			
Oct. 1.	To balance		$549 48
	To amount received from Comptroller	$12,000 00	
	Less balance due appropriation 1899-1900	2,000 00	
			10,000 00
			$10,549 48

Expenditures.

Oct. 1.	By chemical supplies	$507 23
	By contingent expenses	4 07
	By freight and express	48 40
	By heat, light and water	530 95
	By postage and stationery	4 48
	By publications	1,337 52
	By salaries	4,992 36
	By seeds, plants and sundry supplies	138 01
	By tools, implements and machinery	90
	By traveling expenses	778 40
		$8,342 32
	By balance	2,207 16
		$10,549 48

CONCENTRATED FEEDING STUFFS INSPECTION, APPROPRIATION 1900–1901.

Receipts.

1900.			
Oct. 1.	To balance on hand		$329 44
	To amount received from Comptroller	$3,000 00	
	Less balance due appropriation 1899-1900	500 00	
			2,500 00
			$2,829 44

Expenditures.

1900.			
Oct.	1.	By contingent expenses	$1 38
		By freight and express	10 20
		By postage and stationery	123 70
		By publications	664 76
		By salaries	1,427 58
		By seeds, plants and sundry supplies	12 71
		By traveling expenses	318 89
			$2,559 22
		Balance October 1, 1901	270 22
			$2,829 44

SECOND JUDICIAL DEPARTMENT, APPROPRIATION 1900-1901.

Receipts

1900-1901.		
	To amount received from Comptroller	$8,355 10

Expenditures.

By chemical supplies	$71 80
By contingent expenses	238 50
By fertilizers	12 70
By freight and express	28 78
By furniture and fixtures	18 42
By heat, light and water	73 27
By labor	702 96
By library	52 10
By postage and stationery	37 87
By publications	1,782 47
By salaries	3,753 96
By scientific apparatus	85
By seeds, plants and sundry supplies	214 50
By tools, implements and machinery	165 38
By traveling expenses	735 63
By rents	465 91
	$8,355 10

PARIS GREEN LAW, APPROPRIATION 1898–1899.

Receipts.

1900–1901.

To amount received from Comptroller..	$250 80

Expenditures.

By publications......................	$250 80

SPECAL APPROPRIATION, BUILDING AND REPAIRS, APPROPRIATION 1898–1899.

Receipts.

1900–1901.

To amount received from Comptroller..	$117 69

Expenditures.

By building and repairs...............	$117 69

FERTILIZER LICENSE, CHAPTER 955, LAWS 1896, AMENDED BY CHAPTER 687, LAWS 1899.

Receipts.

1900–1901.

To amount received for fertilizer license.	$10,880 00

Expenditures.

By amount remitted to Treasurer State of New York......................	$10,880 00

FEEDING STUFFS LICENSE, CHAPTER 338, LAWS 1893, AMENDED BY CHAPTER 510, LAWS 1899.

Receipts.

1900–1901.

To amount received for feeding stuffs license	$3,150 00

Expenditures.

By amount remitted to Treasurer State of New York......................	$3,150 00

SPECIAL APPROPRIATION 1900–1901, DIRECTOR'S HOUSE.

Receipts.

1900–1901.	
To amount received from Comptroller..	$6,981 76

Expenditures.

By construction Director's house.......	$6,981 76

THE UNITED STATES APPROPRIATION, 1900–1901.

Dr.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1901, as per act of Congress approved March 2, 1887	$1,500 00

Cr.

By publications.......................	$803 15
By postage and stationery.............	50
By heat, light, water and power........	21 89
By chemical supplies..................	33 50
By seeds, plants and sundry supplies...	147 17
By feeding stuffs......................	82 09
By library............................	62 09
By furniture and fixtures..............	75 00
By scientific apparatus................	69 44
By traveling expenses.................	126 04
By contingent expenses................	79 13
	$1,500 00

All expenditures are supported by vouchers approved by the Auditing Committee of the Board of Control and have been furnished the Comptroller of the State of New York.

WILLIAM O'HANLON,
Treasurer.

DIRECTOR'S REPORT FOR 1901.*

To the Honorable Board of Control of the New York Agricultural Experiment Station:

Gentlemen.—I have the honor to present herewith a report for the year 1901 of the institution under your charge. As in former years, this report, outside of the matter dealing with the various lines of inspection, is made up chiefly of the results of investigations and experiments of a scientific or semi-scientific character. In other words, it is mainly a presentation of the outcome of efforts to study problems or conditions important to the practice of agriculture and is not intended, for the most part, to convey information of a common or general character. This is in accordance with the well established policy of holding the Station to the work of investigation rather than of instruction, a policy entirely harmonious with fundamental conceptions and the legal provisions applying to this institution.

The contents of this report make it very evident also that, excepting the inspection work, the members of the Station staff are dealing largely with problems particularly affecting the dairy and horticultural interests, a condition of things quite consistent with the status and demands of the agricultural industries of New York. Dairying is predominant in the stock husbandry of the State and the commanding importance of our gardening and fruit interests cannot be denied by any one familiar with the facts. Moreover, in dairying and fruit growing there come to the front certain questions of a chemical, botanical, bacteriological or entomological character, so specific and so well defined, that they offer promising and useful oppor-

*A reprint of Bulletin No. 211.

tunities for research. In addition to the above considerations, the dairymen and fruit growers are well organized for discussion and for the insistent presentation of their needs and so are likely to receive their full share of attention at the hands of this or any other State institution which is concerned with their interests.

STATION STAFF.

Several changes have occurred in the Station staff during the past year. Heinrich Hasselbring, B.S.A., Assistant in Horticulture, was called, at an increased salary, to the position of Assistant Botanist in the agricultural department of the University of Illinois. His place has been filled by the election of Nathaniel O. Booth, B. Agr., who previously occupied a similar position in the University of Missouri. Mr. Booth is a graduate from the University of Missouri in the course in agriculture, and before coming to New York had shown himself capable of successful work in experimental horticulture.

Amasa D. Cook, Ph.C., after serving the Station for more than eight years as Assistant Chemist, resigned his place at the end of his year's leave of absence in order to continue his studies at Cornell University.

Edwin B. Hart, B.S., returned from Europe in August after a year's study with Professor A. Kossel, Marbourg, and at Heidelberg, Germany, where he devoted his attention chiefly to the chemistry of the proteids.

Harry J. Eustace, B.S., a graduate from the Michigan Agricultural College, was selected as student assistant in botany and will spend the larger part of 1902 at the Station, devoting some weeks to special studies at Cornell Uuniversity.

It was decided by vote of your board to abolish the position of Second Assistant Horticulturist and create a new position to be known as Foreman in Horticulture. After competitive examination Orrin M. Taylor was selected for that position, and has entered upon his duties in immediate supervision of the practical execution of experiment details in the orchards, gardens and forcing houses.

J. Arthur LeClerc, B.S., was granted one year's leave of absence for further study, to take effect September 1, 1901. Mr. LeClerc is now in Europe.

BUILDINGS AND EQUIPMENT.

The completion of a house for the Director of the Station marks another step in the progress of the institution. It is gratifying to note that the legislature of 1901 appropriated $8,500 for the repairs of the original Station building so long jointly occupied by the Director's family and part of the business offices. It is expected that before another year elapses all the administrative work of the Station will be located in this building in such a way as to greatly increase convenience and efficiency.

THE MAILING LIST.

The mailing list has reached the highest point since the establishment of the Station. Its growth is steady, and because its enlargement is not forced by any special effort, it measures in a general way the rate of development of the influence of the Station.

POPULAR BULLETIN LIST.

Residents of New York	34,100
Residents of other States	1,150
Newspapers	767
Experiment stations and their staffs	785
Miscellaneous	131
Total	36,933

COMPLETE BULLETIN LIST.

Experiment stations and their staffs	785
Libraries, scientists, etc	261
Foreign list	115
Individuals	1,390
Miscellaneous	131
Total	2,682

WORK IN THE SECOND JUDICIAL DEPARTMENT.

In 1894 special work was instituted in the Second Judicial Department. This effort was doubtless brought about by the conditions prevailing in the immediate vicinity of New York

City where long established and intensive agriculture had come to have serious problems relating to fungoid and insect pests.

It was thought best by those administering the affairs of the Station at that time to establish a branch office at Jamaica, L. I., as a center from which to work. This was probably a wise arrangement under the conditions then prevailing. Since that time the Station has become more fully organized into well defined departments and it is now clearly good policy to so rearrange the administration of our outside experimental work as to bring the responsibility and details directly to the several departments of the Station. Moreover, there appears to be no good reason for the extra expense attending a branch office because of duplication of men and equipment. Acting in accordance with these views your Board voted to discontinue the branch office at Jamaica after June 30, 1902. It is definitely understood that this action is in no way to affect the character or extent of the experiments conducted in Eastern New York unless it have the effect of enlargment and greater efficiency, and any assertions to the contrary by the uninformed should be discredited.

INSPECTION WORK.

The inspection of fertilizers, feeding stuffs, Babcock glassware and insecticides has come to absorb a generous share of the energy of the Station staff.

The data collected for 1901 is briefly summarized in what follows:

Inspection of fertilizers.—During the year 1901, there were collected for analysis 963 samples of commercial fertilizers, representing 456 different brands; of these 324 brands were complete fertilizers. The average amounts of plant-food constituents found and guaranteed are as follows:

	Nitrogen. Per ct.	Available phosphoric acid. Per ct.	Potash. Per ct.
Guaranteed	1.89	7.67	4.13
Found	2.01	8.80	4.47

In six cases, the nitrogen and phosphoric acid were more than 0.5 per ct. below guarantee; in 16 cases, the potash was more than 0.5 per ct. below guarantee.

The retail selling price of complete fertilizers averages $25.71 a ton, while the retail cost of the separate ingredients, unmixed, averages $19.81, or $5.90 a ton less than the selling price. The average cost of one pound of plant-food in mixed fertilizers to consumers is as follows: nitrogen, 20.8 cents; available phosphoric acid, 6.2 cents; potash, 5.9 cents.

In 1901, 82 manufacturers paid license fees on 550 different brands of fertilizers. The requirement of a license fee has reduced the number of brands offered for sale from 2,268 to 550.

The inspection of commercial feeding stuffs.—The outcome of the inspection of feeding stuffs is given in Bulletin No. 198. It is shown that 92 manufacturers complied with the law by registering the guaranteed composition of 126 brands, and paying the required license therefor. Sixty-six of these brands were standard feeding stuffs having more or less fixed or definite characteristics, while 60 were feeds compounded from various manufacturing offals, the majority of which contained some inferior ingredient.

The analyses of 297 samples taken by representatives of the Station are reported, representing 98 brands inspected in the fall of 1900 and 101 brands found in the winter of 1901.

The unmixed or standard goods were found to be of fairly uniform quality and practically as good as the guarantees, except in a single instance. The discrepancies occurred with the mixed goods, many of which contained oat hulls, as shown by the percentage of crude fibre present.

Adulteration of corn meal and other grain products appears to be practiced. On the whole, it can be said with good reason that the compounding of feeds and the use of inferior materials for adulteration is a serious menace to the prosperity of the stock keeper if he continues to buy cattle foods freely. These mixtures are inferior in quality in most instances and are sold at prices relatively too high.

Inspection of Paris green and other insecticides.—In forty samples of Paris green examined, the amount of arsenious oxide varied from 56.13 to 62.87 per ct., with an average of 58.10 per

ct.; the water-soluble arsenious oxide, from 0.88 to 2.64 per ct., with an average of 1.28 per ct.; the copper oxide, from 26.53 to 31.14 per ct., with an average of 29.88 per ct., and the arsenious oxide in combination with copper, from 49.70 to 57.72 per ct., with an average of 55.98 per ct. These results indicate that the Paris green in the market during 1901 was of good quality in every respect.

Inspection of Babcock glassware.—In 1901 the Station tested glassware for seventy-seven cheese factories and creameries, including 3,473 milk test bottles, 56 cream bottles and 97 pipettes. Of these 119 were found incorrect and rejected.

The Station is not required to inspect cheese factories and creameries to determine whether they are complying with the law as to Babcock glassware. The responsibility in respect to this compliance rests entirely with those having the management of the factories and creameries.

ANIMAL HUSBANDRY.

The food source of milk fat.—The results reported in Bulletin No. 197, relating to the food source of milk fats, were in continuation of the investigations discussed in Bulletin No. 132.

The conclusion reached in the former experiment that part, at least, of the milk fat comes from the carbohydrates is confirmed; and other facts relating to metabolism and the utilization of food by milch cows are brought out.

Three cows were used: Cow 12 fed a fat-poor ration in which the protein supply was gradually decreased from 2.6 lbs. daily to 1.6 lbs. and then gradually restored to the maximum, with accompanying increase and decrease in carbohydrates so that the digestible dry matter of the ration was kept fairly uniform; Cow 10 fed a ration with normal supply of fat at first which was gradually increased to 1.4 lbs. daily, then gradually restored to the normal; Cow 2 fed the herd ration having a nutritive ratio about 1:5.6. These rations were quite varied in character and contained some fat-extracted foods; yet they showed a quite uniform digestibility of about 70 per ct. of the dry matter. It is

believed that this figure represents fairly the digestibility of rations made up in part of silage and containing a fair proportion of high-class grains. A widening of the nutritive ratios appeared to render rations less digestible, especially the protein. The marked changes in protein content and in fat content of rations did not produce noticeable changes in the character or composition of the milk. In the former test, during 59 days, 18.4 lbs. of fat was formed in the milk which could not have had its source in food fat or food protein and could hardly have been drawn from the cow's body fat as she increased in weight 33 lbs. in the same time. In the second test Cow 12 in 74 days produced 39 lbs. of fat similarly unaccounted for, with a body gain of 15 lbs., and Cow 2 in 4 days, 1¼ lbs. These amounts of fat must have come from the carbohydrates in the food.

A lessening of protein supply in the food did not produce a corresponding decrease of protein in the milk solids, but caused a marked lessening of protein decomposition in the body. Calorimeter determinations show that the heat value of urine bears no constant relation to its nitrogen content, and also prove that the formula used in computing heat energy of urine, Nx5.343 Cal., is greatly in error, actual results being from 3 to 4 times as large as calculated by this formula. The energy value of nutrients as given by Rubner—protein and carbohydrates each 4.1 Cal. and fats 9.3 Cal.—appear to be fully high enough for herbivora, even when the loss due to escape of unoxidized gases, methane chiefly, is not considered.

Over 40 per ct. of the available energy value of the rations was used for maintenance, over 30 per ct. reappeared in the milk solids, leaving a balance of from one-fifth to one-fourth of the ration. The logical conclusion is that this balance, in part at least, sustains the work of milk secretion.

The immediate effect on milk flow of changes in the composition of the ration.—A large number (nearly 1,000) of the individual records from a daily herd have been averaged according to different relations in the constituents of the food to show the

general tendency of certain changes to affect the milk flow, Observations were made in this case only in regard to the immediate effect of these changes.

Only rations which approximated those of the common feeding standards were considered. Within these limits changes in the amount of total digestible organic matter showed a greater and more constant influence than any other. An increase in amount of the total nutrients had a generally favorable effect on the milk yield, and a reduction an unfavorable one, either when the amount was more or less than the 15.5 lbs. per day for each 1,000 lbs. live weight.

Changes in the fuel value of the ration showed effects corresponding to those in amount of total nutrients both above and below the value of 30,000 Calories.

Changes in the protein content of the ration within the ordinary limits showed less effect than changes in the amount of nutrients. In general an increase in the amount of protein up to 2.5 lbs. per day for each 1,000 lbs. live weight affected the milk flow favorably. Above that amount, for ordinary cows, a reduction had a favorable effect.

The effects of changes in the nutritive ratio corresponded in a general way to those following changes in the protein content.

DEPARTMENT OF BACTERIOLOGY.

Much of the work performed in the department was a union of effort with the chemical department in studying the factors which are operative in the curing of cheese and so far as reported this is summarized in what is presented from the chemical department. Study has also been given to certain cheese troubles, a report of which will be made after the accumulation of further data.

DEPARTMENT OF BOTANY.

Currant anthracnose.—In the Hudson Valley there has been an epidemic of currant anthracnose, a fungous disease which causes the leaves to fall prematurely. Much damage was done.

In some cases the yield of fruit was reduced one-half. This unusual outbreak furnished an excellent opportunity for the study of the disease. It has been discovered that the fungus attacks not only the foliage, but also the fruit, fruit stems and canes; that some varieties, notably Wilder and Prince Albert, are very resistant to the disease; and that plants in high situations on dry soil are more affected than those growing in low situations on moist soil. There is no cause for alarm. It is improbable that the disease will continue to be destructive, but in case it should do so it can probably be controlled by spraying with Bordeaux mixture.

Trouble with pears in a nursery cellar.—The Station Botanist has investigated a case in which pear trees stored in a nursery cellar were severely injured by being thawed too quickly. The sand around the roots of the trees had become frozen and to facilitate the removal of the trees a small wood fire was built to thaw the sand. The tops of 25,000 trees were blackened and killed. Had the trees been thawed very gradually it is probable that no injury would have resulted.

Cherry shot-hole fungus.—Heretofore it has been supposed that the common shot-hole fungus of plums and cherries, *Cylindrosporium padi*, confines its attacks to the leaves; but during the past season the discovery has been made that, on sour cherries, it also attacks the fruit pedicels with great severity. This discovery is of scientific interest chiefly and has no important bearing on the treatment of the disease.

Anthracnose of cultivated snapdragon.—Our last report contained an account of a destructive anthracnose affecting the Antirrhinum or cultivated snapdragon. Recently it has been discovered that the same disease attacks the yellow toad-flax, *Linaria vulgaris*, a common weed closely related to the Antirrhinum. This fact makes the prevention of the disease somewhat more difficult than we have supposed it to be.

Imperfect fertilization of peaches.—Through imperfect fertilization of peach blossoms there may come about a condition somewhat resembling the dreaded "little peach" disease. However,

the two troubles may be readily distinguished by the fact that imperfectly fertilized peaches have undersized pits containing no kernel or else only a partially developed one; whereas, in the "little peach" disease the pit is of normal size and contains a well developed kernel.

Tile drain clogged by fungus.—At Milton, N. Y., the three-inch tile drain to a vinegar cellar became completely clogged by an unusually luxuriant growth of the fungus *Leptomitus lacteus.* The obstruction was readily removed by placing a handful of copper sulphate crystals in the upper end of the drain.

Fungus in refrigerators.—The water pipes to refrigerators often become clogged with a dark-gray, slimy substance. The principal part of this slime consists of a fungus which is a vegetable growth and not an accumulation of matter from the ice. It may be removed by occasionally pouring boiling water through the waste pipe.

DEPARTMENT OF CHEMISTRY.

Conditions affecting cheese curing. (1) *Conditions affecting loss of weight.*—Loss of weight in cheese during ripening is due mainly to evaporation of moisture from cheese and, at long-continued temperatures above 70° F., to leakage of fat. Loss of weight varies with following conditions: (1) Amount of moisture originally in cheese; the greater the percentage of moisture in the cheese the more rapid and greater the loss of moisture. (2) Temperature of curing-room; the higher the temperature the greater and more rapid the loss of moisture. (3) The degree of saturation with moisture in air of curing-room; the more moist the air the less rapid the loss of weight. (4) The size and shape of cheese; increase of height or diameter of cheese decreases the rapidity of relative loss of weight. (5) The texture of cheese; the closer and more solid the texture, the less rapid the loss of moisture.

These results point conclusively to the necessity of providing curing-rooms in which the conditions of moisture and temperature can be controlled. Lower temperatures with proper

amount of moisture in air result in larger amounts of cheese to sell and at the same time cheese of better quality.

(2) *A study of enzymes in cheese.*—Methods of making and curing cheese improve slowly, because we do not yet know with certainty what agent or agents are the causes of cheese ripening. During the past three years the chemical and bacteriological departments have been making a careful study of the factors that are commonly regarded as the active ones in producing ripening of cheese. The results, as far as published, appear to indicate that neither the enzymes secreted in cows' milk nor those produced by bacteria in the milk previous to its being made into cheese are to be regarded as the most prominent factors in normal cheese ripening.

DEPARTMENT OF ENTOMOLOGY.

Spraying experiments with crude petroleum.—Series I of these tests included the experiments to determine the effect of crude petroleum upon normal trees, and Series II the experiments to determine the percentage of petroleum in an emulsion with water required to kill the San José scale. Three hundred and twenty-one fruit trees were included in these experiments, consisting of apples, cherries, pears, peaches and plums. The results were fairly uniform. In the experiments of Series I no injury was caused by the 25 per ct. emulsion except to peach trees, but in every case 40 per ct. and higher percentages caused serious injury to European plum trees, and to apple trees when the emulsion was applied during the fall or winter. Early spring applications of the 40 per ct. emulsion did not injure apple trees. Pear and cherry trees were not harmed by the emulsion or undiluted petroleum even when applied during the fall or winter.

The experiments to ascertain the percentage of petroleum required to kill the hibernating scales also gave uniform results. The 25 per ct. emulsion failed to affect the scales materially while the 40 per ct. and higher percentages killed them in every instance.

Taken as a whole these experiments indicate the following:

1. Vigorous trees are probably less liable to injury by crude petroleum than weak ones.

2. Peach and plum trees are more sensitive to crude petroleum than apples, cherries or pears.

3. There is less danger of injury if trees are sprayed in early spring than during the fall or winter.

4. The 25 per ct. emulsion of crude petroleum and water cannot be depended upon to kill the hibernating scales in the latitude of western New York while the 40 per ct. has proven efficient.

5. Much pains should be taken to avoid over-drenching the trees. Only enough of the emulsion should be applied to wet the bark evenly and thoroughly.

Washes.—The resin-lime mixture and government whitewash did not adhere to the trees well and apparently had but little effect on the scales.

Fumigation.—The fumigation experiments in western New York with hydrocyanic acid gas were also divided into two series. Series I included the experiments to determine the effect of the gas upon bud sticks for budding purposes, and Series II the strength of the gas required to kill the hibernating scales. In both series the gas was used at strengths varying from .18 to .3 gram of cyanide of potassium per cubic foot of air space. The exposure of the buds to the gas varied from one-half hour to one hour.

The experiments with buds, while not entirely satisfactory owing to the somewhat unfavorable conditions surrounding the treated buds, gave sufficiently uniform results to indicate clearly that the gas is harmless except in the case of the peaches, which were evidently injured slightly by the gas at .3 gram of cyanide. There was but little difference in the percentage of treated buds that set and the checks. In all 4,483 buds were treated, 78 per ct. of which set. The checks numbered 4,861, of which 85.5 per ct. set, making but a slight difference in their favor. This differ-

ence was probably due in large part to imperfect protection and accidents to the treated buds after setting.

The experiments of Series II resulted in a failure to kill the scales during the winter with gas of less strength than .3 gram of cyanide. The spring treatment gave different results. The gas at a little more than half the strength (.18 gram) killed the scales in every case and did not injure the foliage.

In tests made on Long Island the conclusion was reached that it is possible to exterminate the scale in small, isolated orchards of small trees by fumigation. Under favorable circumstances the gas from .15 gram of cyanide per cubic foot of space sufficed to kill the scales; but where the fumigation is done over damp soil, or when the trees are wet, it is best to use twice this amount as the gas is rapidly absorbed by water, thus reducing the percentage in the air. It is safe to use gas of this strength (.3 gram of cyanide per cubic foot) for from 30 to 60 minutes upon all dormant orchard trees.

Trials of different proportions of cyanide, acid and water in the formula for generating the gas in fumigation showed that 1 part of lump cyanide by weight, $1\frac{1}{2}$ times as much acid by volume and 3 times as much water by volume gave complete, rapid and not too violent chemical action. This formula differs but slightly from the commonly used formula ($1-1\frac{1}{2}-2\frac{1}{4}$); so that the latter may be followed if preferred, using a little more water if the action seems too violent.

Promising insecticides.—Certain insecticides which were tried as most promising remedies for the San José scale, but which require further tests to demonstrate their value are whale-oil soap and crude petroleum compound, the lime-sulphur-and-salt wash and a kerosene-lime emulsion.

Modification of the Station fumigator.—This consists of a new method of holding the door in place. Instead of buttons, four strips extend across the front of the door and project about three inches on each side. The projecting ends are cut on a bevel and fit against corresponding surfaces of blocks fastened to the sides of the fumigator. As the door is pressed down it is forced securely into place.

Hexagonal folding fumigator.—For the work on Long Island a new form of fumigator was devised, which possesses some advantages over all other forms. This is hexagonal in form, with sides hinged to allow of folding into compact form for transportation and storage, and with removable folding top. In operation the box is held rigid by the top and by braces at the bottom. Two sides and part of the top swing back easily to allow of placing the fumigator about the tree to be treated. The hexagonal form avoids waste space about the tree.

DEPARTMENT OF HORTICULTURE.

The forcing of lettuce has come to be one of the important industries connected with market gardening in this and adjacent States. In 1895 a line of experiments was undertaken at this Station bearing upon practical problems which are to be met in the business of forcing lettuce. The first report on this line of work was given in 1898, in Bulletin 146, and also in the Station's Annual Report for that year. This report treated of "Soil Mixture for Forcing Lettuce," and "The Use of Commercial Fertilizers in Forcing Head Lettuce." In the conclusions therein set forth it was stated that when the soil was fertilized with heavy applications of stable manure no advantage seemed to follow the addition of either sulphate of potash, acid phosphate or nitrate of soda. On the clay loam mixed with 15½ per ct. stable manure by weight a slight increase in growth followed the addition of nitrate of soda. Since 1898 the investigations have been continued each year for the purpose of gaining further information on the economical use of commercial fertilizers in forcing lettuce either when used alone or in combination with stable manure. Nitrogenous commercial fertilizers were tried alone and in combination with various percentages of manure. The tests were made with loose lettuce and head lettuce both on a medium clay loam and a light sandy loam. The nitrogenous commercial fertilizers which were compared were nitrate of soda, at the rate of 600 lbs. per acre, sulphate of ammonia 480 lbs. per acre, dried blood 1,000 lbs. per acre, and a combination

of 850 lbs. of dried blood and 100 lbs. nitrate of soda per acre. The amount of nitrogen thus applied was approximately the same in each case.

The use of these commercial fertilizers with no manure was followed by a much better yield of lettuce than that produced by similar soil not fertilized. On the clay loam the use of the nitrate of soda without manure was followed by a better yield than followed the use of either sulphate of ammonia or dried blood without manure. On the sandy soil without manure dried blood generally gave better results than either the sulphate of ammonia or the nitrate of soda. With sulphate of ammonia and no manure the yields were very variable. These nitrogenous fertilizers alone, in the amounts applied, proved inadequate for forcing lettuce in a sufficiently short time to be profitable. Very much better crops were obtained when stable manure was added.

The higher percentages of manure when combined with the nitrogenous commercial fertilizers above named obscured the action of the latter so that it was not possible to decide that any advantage was obtained from adding them with the manure. With the smaller percentages of manure (5 per ct. and 10 per ct.) the addition of dried blood gave in the aggregate better results than either nitrate of soda or sulphate of ammonia similarly combined.

When 5 per ct. of manure was added to the soil with the commercial fertilizers referred to, the yields were invariably very much increased over those obtained with the same fertilizers and no manure. Double, triple and quadruple portions of manure increased the yield of the first crop but not to a corresponding extent. With succeeding crops the cumulative effect of successive heavy applications of manure was seen in the actual decrease of the yield below that obtained with more moderate applications of manure.

In forcing lettuce it is not uncommon for gardeners to use from 5 per ct. to 20 per ct. of manure. The amount which they use doubtless most often approaches the 20 per ct. rate. In

these experiments repeated applications at the rate of 15 per ct. to 20 per ct. of manure proved not only wasteful of manure but also lessened the yield.

As in the previous experiments reported in Bulletin 146 the clay loam gave better crops of lettuce than the sandy loam when both were given equal amounts of stable manure.

The amount of manure which it is economical to use in forcing lettuce necessarily varies with the character of the manure and of the soil. It also would vary to some extent with the difference between the prices received for fancy lettuce and those received for the ordinary grades. For these rasons definite amounts cannot be recommended.

CROP PRODUCTION.

Commercial fertilizers in onion growing.—Experiments in the use of different quantities of a complete fertilizer in growing onions were conducted at Florida, Orange Co., N. Y., for four years on the same field and for one year on a field of another farm.

The quantities of fertilizer used per acre were none, 500 lbs., 1000 lbs., 1500 lbs. and 2000 lbs.

On the Purdy field (4 years), when only 500 lbs. of fertilizer was used the manure cost of the increase of crop was 16.6 cts. per barrel; with 1000 lbs., 79.3 cts., with 1500 lbs., 80.4 cts., and with 2000 lbs., 227.8 cts.

The profit from using the fertilizer came mostly from the first 500 lbs. applied, averaging $35.84 per acre. With onions at $1.25 per barrel the profit was slightly larger (about $3 per acre), with both the 1000 lbs. and 1500 lbs. of fertilizer per acre; but 2000 lbs. was used at a loss.

On the Mars field one experiment was conducted which showed no increase of yield from applying commercial fertilizer even in the larger quantities.

The results of these experiments show clearly that the crops were limited more by other conditions than by the extent of the plant food supply. With the best conditions of season and water

supply the smallest amount of fertilizer supported the maximum crop.

Considering the varying market price of onions from one year to another and the various vicissitudes to which the crop is subjected, the use of the larger quantities of fertilizer (above 500 lbs.) was attended by danger of financial loss.

Effect of manures on sugar beets.—These experiments were undertaken to test the accuracy of the statement that sugar beets are of an inferior quality when grown on land to which stable manure is applied in the spring.

The experiments have been conducted during four consecutive years, mostly on the Station farm. Comparisons have been made of the quality of beets not manured, those grown with commercial fertilizer, mostly 1000 lbs. per acre, and those grown on land receiving in the spring, before planting the beets, from 40,000 lbs. to 80,000 lbs. stable manure per acre. Beets from at least six varieties of seed were grown during the four years.

The results are almost unanimous in one direction. The beets have been of high quality with all three methods of treatment, averaging somewhat better with the farm manure than with no manure or with commercial fertilizers.

BULLETINS PUBLISHED IN 1901.

No. 197. October.—The food source of milk fat; with studies on the nutrition of milch cows. W. H. Jordan, C. G. Jenter and F. D. Fuller. Pages 32.

No. 198. November.—Inspection of feeding stuffs, 1900-1901. W. H. Jordan and C. G. Jenter. Pages 29.

No. 199. November.—An epidemic of currant anthracnose. F. C. Stewart and H. J. Eustace. Pages 18, plate 1.

No. 200. November.—Notes from the Botanical Department: Trouble with pears in a nursery cellar; shot-hole fungus on cherry fruit pedicels; anthracnose of yellow toad-flax; imperfect fertilization of peaches; tile drain clogged by fungus; a fungus in refrigerators. F. C. Stewart and H. J Eustace. Pages 21, plates 4.

No. 201. December.—Report of analyses of commercial fertilizers for the spring and fall of 1901. L. L. Van Slyke and W. H. Andrews. Pages 66.

No. 202. December.—San José scale investigations, III: Spraying experiments with crude petroleum and other insecticides; fumigation experiments with hydrocyanic acid gas; other promising insecticides; a modification of the Station fumigator. V. H. Lowe and P. J. Parrott. Pages 46, plates 2, figure 1.

No. 203. December.—A study of enzymes in cheese. L. L. Van Slyke, H. A. Harding and E. B. Hart. Pages 30.

No. 204. December.—Inspection of Paris green and other insecticides, 1901. L. L. Van Slyke and W. H. Andrews. Pages 6.

No. 205. December.—Influence of manure on sugar beets. W. H. Jordan and G. W. Churchill. Pages 14.

No. 206. December.—Commercial fertilizers for onions. W. H. Jordan and F. A. Sirrine. Pages 10.

No. 207. December.—Conditions affecting weight lost by cheese in curing. L. L. Van Slyke. Pages 30, figures 6.

No. 208. December.—Stable manure and nitrogenous chemical fertilizers for forcing lettuce. S. A. Beach and H. Hasselbring. Pages 36, plates 10.

No. 209. December.—Treatment of San José scale in orchards, I: Orchard fumigation. F. A. Sirrine. Pages 29, plates 10.

No. 210. December.—Effect on milk production of change of rations. W. P. Wheeler. Pages 63.

No. 211. December.—Director's report for 1901. W. H. Jordan. Pages 19.

W. H. JORDAN,
Director.

New York Agricultural Experiment Station,
Geneva, N. Y., Dec. 31, 1901.

REPORT

OF THE

Department of Animal Husbandry.

W. H. JORDAN, *Director.*

W. P. WHEELER, *First Assistant.*

C. G. JENTER, *Assistant Chemist.*

F. D. FULLER, *Assistant Chemist.*

TABLE OF CONTENTS.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

THE FOOD SOURCE OF MILK FAT; WITH STUDIES ON THE NUTRITION OF MILCH COWS.*

W. H. JORDAN, C. G. JENTER AND F. D. FULLER.

The tests herein reported are in continuation of one given in Bulletin 132 relating to the food source of milk fats. The conclusion reached in that experiment, that part, at least, of the milk fat comes from the carbohydrates, is confirmed; and other facts relating to metabolism and utilization of food by milch cows are brought out.

Three cows were used: Cow 12 fed a fat-poor ration in which the protein supply was gradually decreased from 2.6 lbs. daily to 1.6 lbs. and then gradually restored to the maximum, with accompanying increase and decrease in carbohydrates so that the digestible dry matter of the ration was kept fairly uniform; Cow 10 fed a ration with normal supply of fat at first which was gradually increased to 1.4 lbs. daily, then gradually restored to the normal; Cow 2 fed the herd ration having a nutritive ratio about 1:5.6. These rations were quite varied in character and contained some fat-extracted foods; yet showed a quite uniform digestibility of about 70 per ct. of the dry matter. It is believed that this figure represents fairly the digestibility of rations made up in part of silage and containing a fair proportion of high class grains. A widening of the nutritive ratios appeared to render rations less digestible, especially the protein. The marked changes in protein content and in fat content of rations did not produce noticeable changes in the character

*A reprint of Bulletin No. 197.

or composition of the milk. In the former test, during 59 days, 18.4 lbs. of fat was formed in the milk which could not have had its source in food fat or food protein and could hardly have been drawn from the cow's body fat as she increased in weight 33 lbs. in the same time. In this test Cow 12 in 74 days produced 39 lbs. of fat similarly unaccounted for, with a body gain of 15 lbs.; and Cow 2, in 4 days, 1¼ lbs. These amounts of fat must have come from the carbohydrates in the food.

A lessening of protein supply in the food did not produce a corresponding decrease of protein in the milk solids, but caused a marked lessening of protein decomposition in the body. Calorimeter determinations show that the heat value of urine bears no constant relation to its nitrogen content, and also prove that the formula used in computing heat energy of urine, Nx5.343 Cal., is greatly in error, actual results being from 3 to 4 times as large as calculated by this formula. The energy values of nutrients as given by Rubner,—protein and carbohydrates each 4.1 Cal. and fats 9.3 Cal. appear to be fully high enough for herbivora, even when the loss due to escape of unoxidized gases, methane chiefly, is not considered.

Over 49 per ct. of the available energy value of the rations was used for maintenance, over 30 per ct. reappeared in the milk solids, leaving a balance of from one-fifth to one-fourth of the ration. The logical conclusion is that this balance, in part at least, sustains the work of milk secretion.

INTRODUCTION.

Bulletin No. 132 of the New York Agricultural Experiment Station presented the results of an experiment to determine the sources of milk fat as related to the food supply. The main conclusion therein stated was that milk fat can be formed in part, at least, from carbohydrates, the data of the experiment pointing to this conclusion in a most convincing way. It was felt, however, that so important a generalization, if correct, should be supported by results secured with more than one animal. An opportunity was desired also for enlarging the scope of the observations. Experiments have been conducted, therefore,

with three other cows and the data thus obtained not only furnish additional evidence concerning the main question of the source of milk fat but have been used in studying other questions relating to the metabolism of the milch cow. The publication of the results secured has been much delayed, largely because of the great amount of work involved in the investigations.

THE PLAN, MATERIALS AND PROCEDURE OF THE EXPERIMENTS.

THE FORMER EXPERIMENT.

In the experiment previously reported the cow was fed a normal ration for a time; then, for 95 days, she was given foods that, because of extraction, contained very small proportions of ether extract.

During 66 days the solid and liquid excreta were collected for analysis and daily analyses of the milk were made for a longer period. The quantity of the ration and the nutritive ratio were varied in a way calculated to show the influence of the protein supply upon fat secretion. The experiment was so planned as to make it impossible for the milk fat to have its source wholly in the protein and ether extract of the food and so long continued that any material draft upon the body of the cow for milk production would produce a marked change in the condition and weight of the animal. (For details see Bulletin 132.)

THE NEW EXPERIMENTS.

The later experiments involved the use of three cows quite unlike in their characteristics and productive capacity, each of which received a ration distinctly different from the rations given the other two.

(1) Cow 12, a grade Shorthorn weighing about 1,200 pounds, fresh in milk at the beginning of the experiment and not pregnant, was fed for 88 days a ration containing little ether extract, the nutritive ratio being very gradually varied from narrow to wide and back again, the total quantity of digestible dry matter consumed daily being maintained at a fairly uniform quantity.

A record of the amount and composition of the food, milk and excreta was kept for 74 days.

(2) Cow 10, a grade Jersey weighing about 750 pounds, fresh in milk at first and not pregnant, was fed a mixture of normal feeding stuffs for 68 days, the fat in which was varied from a proportion fully as large as is ever found in practice to a quantity somewhat excessive, the daily supply of digestible matter remaining quite constant. A record of the amount and composition of the food, milk and excreta was kept for 54 days.

(3) Cow 2, a full blood Jersey, of very large productive capacity and in full milk flow, weighing about 780 pounds, was fed the usual herd ration. The amount of food was accurately weighed for 20 days and the milk and excreta were weighed and analyzed for the last four.

THE FOODS.

The feeding stuffs used in these experiments, some of them normal and some having been submitted to a petroleum extraction, had the following composition:

COMPOSITION OF FEEDING STUFFS.

Lab. No.		Water. *Per ct.*	Ash. *Per ct.*	Nitrogen. *Per ct.*	Protein.* *Per ct.*	Fat (Petroleum extract.) *Per ct.*
712	Mixed hay, Cow 10.........	14.5	6.36	1.62	10.12	1.36
717	Alfalfa hay, Cows 2 and 12..	16.66	6.92	2.39	14.94	1.44
716	Oat straw, Cow 12..........	10.75	5.27	0.33	2.06	1.44
713	Corn meal, Cow 10..........	22.12	1.28	1.24	7.75	2.27
736	Corn meal, Cow 10..........	20.26	1.55	1.35	8.44	1.57
720	Corn meal, extracted, Cow 12	12.36	1.16	1.56	9.75	0.37
740	Corn meal, extracted, Cow 12	11.65	1.14	1.53	9.56	0.37
718	Rice meal, Cow 12..........	12.67	0.31	1.53	9.18	0.11
719	Rice meal, Cow 12..........	11.87	0.34	1.53	9.18	0.09
727	Rice meal, Cow 12..........	13.45	0.60	1.13	6.78	0.31
741	Rice meal, Cow 12..........	12.79	0.38	1.50	9.00	0.08
721	Oats, extracted, Cow 12.....	11.18	3.06	2.20	13.20	0.79
739	Oats, extracted, Cow 12.....	12.67	2.98	2.	12.	0.71
745	Wheat bran, Cow 2.........	11.21	1.29	2.44	13.91	4.33
746	Malt sprouts, Cow 2........	10.46	5.38	4.22	25.32	1.67
714	Linseed meal, Cow 10......	7.65	4.75	5.96	32.78	6.71
737	Linseed meal, Cow 10......	9.48	4.78	5.84	32.12	7.07
747	Linseed meal, Cow 2.......	9.52	4.64	5.85	32.17	6.94
715	Flaxseed, ground, Cow 10...	9.75	2.91	3.34	18.37	37.29
738	Flaxseed, ground, Cow 10...	4.04	3.00	3.42	18.81	38.84
722	Wheat gluten, Cow 12......	7.16	0.33	13.08	75.54	0.71
723	Wheat gluten, Cow 12......	9.10	0.43	12.64	71.01	0.53
742	Wheat gluten, Cow 12......	6.38	0.72	12.80	72.96	0.94
	Sugar beets†................					

*With hay, oat straw and corn meal, protein = N x 6.25; with rice meal, oats and malt sprouts, protein = N x 6; with wheat, bran and wheat gluten, protein = N x 5.7; with linseed meal and ground flaxseed, protein = N x 5.5.

†Daily analyses of sugar beets were made.

THE RATIONS.

Cow 12.—The daily ration of this animal as established at first was as follows:

Ration of Cow 12.

Alfalfa hay	8 lbs.	Rice meal	$3\frac{1}{3}$ lbs.
Oat straw	8 lbs.	Oats (extracted)	3 lbs.
Sugar beets	27 lbs.	Corn meal (extracted)	2 lbs.
Wheat gluten	$1\frac{1}{2}$ lbs.		

After three weeks, including one week of preliminary feeding, the wheat gluten was diminished one ounce per day and the rice meal was increased by a like amount. This change was continued until no wheat gluten was fed. After seven days of absence of wheat gluten from the ration it was again introduced, one ounce the first day, two ounces the second and so on, the rice meal being diminished to the same extent until the original ration was reached. The feeding was then continued on this basis. It should be said that a uniform addition of 1 pound of rice meal was made to the ration at the end of the first month's feeding.

This method of varying the ration allowed a very gradual change in the protein supply in both directions with no lessening of the supply of digestible organic matter, thus making it possible to study the relation of protein to milk secretion without the disturbing influence of sudden changes in the character of the ration or of a deficiency of carbohydrates.

Cow 10.—The basal ration of this cow consisted wholly of normal foods and was designed to supply a generous amount of vegetable oils.

Ration of Cow 10.

Mixed hay	12 lbs.	Linseed meal	2 lbs.
Sugar beets	27 lbs.	Ground flaxseed	1 lb.
Corn meal	4 lbs.		

The ether extract in this ration at first was about .8 lb. per day and it was maintained at this amount for about one month when it was gradually increased by a substitution of ground flaxseed for a like quantity of linseed meal at the rate of $\frac{1}{4}$ lb. per day until the ether extract ingested daily was 1.4 lbs.

After feeding at this rate for a week the fat was diminished at the same rate as it had been increased by gradually substituting rice meal and extracted corn meal for normal corn meal and the ground flaxseed. The purpose of these changes was to note the effect of the supply of fat upon milk secretion and protein exchange.

Cow 2.—This cow, whose rate of yield was over 2 lbs. of butter per day, was fed essentially the same mixture as was given to the whole Station herd.

RATION OF COW 2.

Alfalfa hay	6 lbs.	Wheat bran	4½ lbs.
Corn silage	40 lbs.	Malt sprouts	2¼ lbs.
Sugar beets	10 lbs.	Linseed meal	2¼ lbs.

This ration was accurately weighed from March 29th to April 18th inclusive, and during the last four days of this time the necessary observations were made in the collection of excreta and weighing of milk.

The quantities of each constituent of the rations which were consumed during the various periods, expressed in grams and so arranged as to easily trace the changes, are shown in the succeeding table:

Rations by Periods.

	Alfalfa hay.	Oat straw.	Sugar beets.	Rice meal.	Corn meal. (Extr.)	Oats. (Extr.)	Wheat gluten.	Corn meal.	Linseed meal.	Flaxseed meal.
Cow 12.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Jan. 9th to Feb. 21st..	3628.8	3628.8	12,247.2	1512.	907.2	1360.8	680.4			
Feb. 22d to Mar. 8th..	3628.8	3628.8	12,247.2	1540.3 to 2617.6	907.2	1360.8	625. to 28.4			
Mar. 9th to Mar. 15th..	3628.8	3628.8	12,247.2	2646.	907.2	1360.8	——			
Mar. 16th to Apr. 7th..	3628.8	3628.8	12,247.2	2617.6 to 1994.	907.2	1360.8	28.4 to 625.			
Apr. 8th to Apr. 14th..	3628.8	3628.8	12,247.2	1965.6	907.2	1360.8	680.4			
Cow 10.	Mixed hay.									
Jan. 9th to Feb. 27th..	5443.2		12,247.2					1814.4	907.2	453.6
Feb. 28th to Mar. 6th..	5443.2		12,247.2					1814.4	793.8 to 113.4	567. to 1247.4
Mar. 7th to Mar. 13th..	5443.2		12,247.2					1814.4	——	1360.8
Mar. 14th to Mar. 25th.	5443.2		12,247.2	113.4 to 1360.8	113.4 to 1360.8			1701. to 453.6		1247.4 to 0

Note.—*Cow 2*, from April 14th to 18th (4 days), received 4536 grams sugar beets, 2721.6 grams alfalfa hay, 18,144 grams corn silage, 2041.2 grams wheat bran, 1020.6 grams malt sprouts and 1020.6 grams linseed meal.

METHODS OF SAMPLING AND ANALYSIS.

The rations were weighed out at several different times during the course of the experiment, and each time this was done samples were taken of the various foods.

The milk, urine and feces were taken directly to the laboratory and immediately weighed and sampled, excepting that the night's milk was kept in an ice box until morning, when it was mixed with the morning's milk and a sample was then drawn from the mixture. The feces were thoroughly stirred and samples (4 lbs.) of the fresh material were taken for drying. These samples were dried over steam coils at a temperature ture not exceeding 60° C.

In general the methods of the A. O. A. C. were followed in the analyses, the only exception being that petroleum ether was used instead of sulphuric ether in extracting the fats from the foods and feces. (See Bulletin 132.)

Nitrogen was determined directly in fresh samples of the urine and feces. The drying of the feces at a temperature varying from 50° to 60° C. caused a material loss of nitrogen, as previous results clearly show. (See Bulletin 132.)

THE RESULTS OF THE EXPERIMENTS.

The results of these experiments are presented without a full statement of the data involved.

The omissions are the daily weights and daily composition of the feces, urine and milk, the figures for which would occupy many pages and would be of use only to those who wish to study the data from some standpoint not considered by the authors.

The points that will be discussed are the following:

(1) The digestibility of the rations, with some reference to the influence upon digestibility of the proportions of nutrients in the case of Cow 12.

(2) The influence of the composition of the ration upon the quantity and composition of the milk and upon the composition of the milk fat.

(3) The source of milk fat and the relation of milk fat formation (a) to protein exchange and (b) to the supply of food fat.

(4) The metabolism of nutrients as affected by the composition of the ration.

(5) The energy value of the digestible portion of a ration.

(6) The distribution of the food energy in maintaining a milch cow.

THE DIGESTIBILITY OF THE RATIONS.

The figures which immediately follow show the extent to which the rations were digested.

DIGESTIBILITY OF RATIONS.

	Dry substance.	Organic matter.	Ash.	Protein.	Carbohydrates.	Ether extract.
Cow 12, during 1st period, 7 days (Jan. 30–Feb. 6)	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
In foods.......	90985.1	86594.5	4390.6	12371.9	73340	882.6
In feces.......	27698.6	24894.7	2803.9	4210.6	19981.8	702.3
Digested	63286.5	61699.8	1586.7	8161.3	53358.2	180.3
Percentage digested.......	69.6	71.3	36.1	66.0	72.8	20.4
Eaten daily, lbs.	19.9	19.4	0.5	2.6	16.8	0.06
	Nutritive ratio 1:6.5					
Cow 12, during 2d period, 7 days (Feb. 19 to 26).						
In foods.......	92657.8	88259.6	4398.2	11261.9	76105.2	892.5
In feces.......	28528.1	25935.1	2593.0	4409.4	20850.1	675.6
Digested	64129.7	62324.5	1805.2	6852.5	55255.1	216.9
Percentage digested.......	69.2	70.6	41.0	60.9	72.6	24.3
Eaten daily, lbs.	20.2	19.6	0.6	2.2	17.4	0.05
	Nutritive ratio 1:8.0					
Cow 12, during 3d period, 8 days March 8 to 16).						
In foods.......	105344.1	100308.7	5035.4	10538.1	88776.6	994.0
In feces.......	34509.2	31587.6	2921.6	4774.4	26077.7	735.5
Digested	70834.9	68721.1	2113.8	5763.7	62698.9	258.5
Percentage digested.......	67.2	68.5	42.0	54.7	70.6	26.0
Eaten daily, lbs.	19.5	18.9	0.6	1.6	17.3	0.07
	Nutritive ratio 1:10.9					

	Dry substance. Grams.	Organic matter. Grams.	Ash. Grams.	Protein. Grams.	Carbohydrates. Grams.	Ether extract. Grams.
Cow 10, period 10 days (Feb. 4th–14th).						
In food........	102388.5	96887.2	5501.3	13178.7	80078.0	3630.5
In feces.......	28023.3	25473.1	2550.2	5114.4	19632.3	726.4
Digested	74365.2	71414.1	2951.1	8064.3	60445.7	2904.1
Percentage digested.......	72.6	73.7	53.6	61.2	75.5	80.0
Eaten daily, lbs.	16.4	15.7	0.7	1.8	13.3	0.6
			Nutritive ratio 1:7.5			
Cow 2, period 4 days (April 14th–18th).						
In food........	48546.0	46284.2	2261.8	7768.1	36982.2	1533.9
In feces.......	15128.5	13730.5	1398.0	2424.5	11275.9	30.1
Digested	33417.5	32553.7	863.8	5343.6	25706.3	1503.8
Percentage digested.......	68.8	70.3	38.2	68.8	69.5	98.0
Eaten daily, lbs.	18.4	17.9	0.5	2.9	14.2	0.8
			Nutritive ratio 1:5.6			

The several rations fed to these cows exhibit a somewhat noteworthy similarity of digestibility. It appears from these and other observations that when a ration is made in part of silage and contains a moderately large proportion of the high class grains not far from 70 per ct. of the dry matter is digested.

In the case Cow 12 an opportunity is given to note the influence upon digestibility of varying the proportion of nutrients.

The data which it is essential to consider are the following:

EFFECT OF VARYING PROPORTIONS OF NUTRIENTS ON DIGESTIBILITY.

Period.	CHANGES IN FOOD.	Digestible organic matter eaten daily. Lbs.	Digestible protein eaten daily. Lbs.	Nutritive ratio.	Organic matter digested. Per ct.	Protein digested. Per ct.
Jan. 30 to Feb. 6...	1½ lbs. wheat gluten fed.	19.4	2.6	1:6.5	71.3	66.0
Feb. 19 to 26......	Wheat gluten partly replaced by rice meal..	19.6	2.2	1:8.0	70.6	60.9
Mar. 8 to 16.......	Wheat gluten wholly replaced by rice meal..	18.9	1.6	1:10.9	68.5	54.7

Much stress has been laid in the past upon the necessity of avoiding too wide a nutritive ratio, that is, too large a proportion of carbohydrates, because of a depression of the digestibility of the ration, especially of the protein. In the case under consideration there appears to be a gradual decrease in the proportion of total organic matter digested from the first to the third periods, and it is logical to conclude that this was caused by a widening of the nutritive ratio, because other conditions remained the same. The protein is also apparently considerably less digestible after the withdrawal of the wheat gluten. This is due in part at least to the high rate of digestibility of the protein in wheat gluten as compared with that in other parts of the ration. Moreover, under these conditions the presence of certain metabolic products would cause an apparent rather than a real decrease in digestibility. The extent of the influence of an increase in the proportion of carbohydrates cannot be seen clearly in this instance, although the evidence in favor of a depression of digestibility is as valid as that from which former conclusions have been drawn.

The foregoing figures make it plain that the several rations furnished abundant and not unusual nutrition to the cows eating them, excepting, of course, the very small amount of fat supplied to Cow 12 and the abnormal supply of fat in the ration of Cow 10 for a short period.

THE INFLUENCE OF THE COMPOSITION OF THE RATION UPON THE QUANTITY AND COMPOSITION OF THE MILK AND MILK FAT.

Before discussing the questions to which these investigations have more especial reference, it is important to inquire whether the quantity and character of the cow's product were in anyway modified by the unusual character or variations of the rations.

This inquiry is all the more pertinent because of the prevailing notion, not yet justified by any researches whatever, that the composition of the ration determines to a large extent the character and composition of the milk.

EFFECT OF VARIATIONS IN RATION UPON THE MILK.

Cow 12. Variations in Protein Supply.

Period.	CHANGES IN RATION.	Milk yield daily.	Solids in milk.	Fat in milk.
		Lbs.	*Per ct.*	*Per ct.*
Jan. 30 to Feb. 6...	Maximum protein fed (2.6 lbs. daily)	35.1	12.92	3.72
Feb. 6 to 16........	Maximum protein fed	32.2	13.04	3.68
Feb. 16 to 26.......	Protein diminishing, carbohydrates increasing	30.1	13.36	3.92
Feb. 26 to Mar. 8...	Protein still diminishing, carbohydrates still increasing	28.4	13.37	3.87
Mar. 8 to 18........	Protein at minimum (1.6 lbs. daily)	26.0	13.47	4.01
Mar. 18 to 28.......	Protein increasing, carbohydrates diminishing	26.1	13.65	4.05
Mar. 28 to Apr. 7..	Protein still increasing, carbohydrates still diminishing	26.5	13.73	4.11
Apr. 7 to 14........	Protein at maximum (2.6 lbs. daily)	26.1	13.78	4.08

Cow 10. Variations in Food Fat Supply.

		Lbs.	*Per ct*	*Per ct.*
Jan. 30 to Feb. 6...	Normal ration (fat fed daily, .8 lb.)	22.9	14.31	4.74
Feb. 6 to 13........	Ration unchanged	22.8	14.20	4.74
Feb. 13 to 20.......	Ration unchanged	22.8	14.20	4.75
Feb. 20 to 27.......	Ration unchanged	23.5	13.90	4.46
Feb. 27 to Mar. 6...	Food fat increasing	23.4	14.09	4.60
Mar. 6 to 13........	Food fat at maximum (1.4 lbs. daily)	23.7	14.17	4.76
Mar. 13 to 20.......	Food fat diminishing	24.6	13.81	4.44

Thre is nothing in these data to warrant the conclusion that supplying more or less protein or more or less fat to a milch cow causes material changes in the milk. In the case of Cow 12 her milk suffered a gradual and quite constant increase in its proportion of solids and of fat, but this change was in no way disturbed in its progress by the fall or rise in the proportion of protein in the food.

With Cow 10, the increase of the food fat to 1.4 lbs. daily, a most abnormal quantity, did not raise the milk fat above what appeared to be the normal proportion. These results stand in accord with the outcome of many other carefully conducted investigations.

The question whether entirely normal milk fat was produced with a fat-free ration, or nearly so, is an interesting one. The

only evidence which these experiments supply along this line was obtained by the partial analysis of the milk fat from the cow which was the subject of the experiments detailed in Bulletin 132. In this experiment the cow was fed a normal ration during a portion of the time she was under observation, so that it is possible to compare the fat produced before and after the food fat was almost entirely withdrawn.

PARTIAL COMPOSITION OF MILK WITH NORMAL AND EXTRACTED FOODS.

Periods represented by different lots of milk fat.	KIND OF RATION.		Average daily yield milk fat.	Reichert number 2½ grams of fat.
			Lbs.	
April 19 to 26....	Normal food.	Food fat daily .63 lb.....	.96	16.3
May 3 to 10.....	Extracted food.	Food fat daily .125 lb....	.74	13.6
May 10 to 17....	Extracted food.	Food fat daily .125 lb....	.76	14.1
May 17 to 24....	Extracted food.	Food fat daily .125 lb....	.75	14.1
May 24 to 31....	Extracted food.	Food fat daily .125 lb....	.65	14.5
May 31 to June 7	Extracted food.	Food fat daily .125 lb....	.60	14.9
June 7 to 14.....	Extracted food.	Food fat daily .125 lb....	.60	14.9

The Reichert number shows the relative proportion of volatile acids in milk fat. As an unmistakable and permanent drop occurred in this number immediately following the substitution of the fat-poor ration for the normal, it is fair to attribnte to the food fat some influence upon the milk fat, though a single observation of this kind should not be taken as conclusive evidence. At the same time, the milk fat produced while the extracted foods were being fed contained a proportion of volatile acids larger than often found with normal rations. That the glycerides of these acids were formed in the cow and were not derived as such from the food is so evident as to render discussion unnecessary.

THE SOURCE OF MILK FAT.

The main question involved in this investigation is the source of milk fat. The importance of the question and the reasons why it seemed to demand further investigation are set forth in Bulletin 132. It is sufficient to state in this connection that the inquiry is concerned with the relation of the several nutrients to

milk fat secretion, whether this fat is derived wholly from fats previously formed in the plant or from protein, or whether carbohydrates may support its formation either directly or through the previous formation of body fat.

The tables which immediately follow give the daily nitr n and fat balance for the three cows. From these tables various summaries are derived which show the bearing of the evidence secured.

BALANCE SHEET OF NITROGEN AND FAT. (COW 12).

DATE.	Nitrogen income.	Nitrogen outgo.				Gain of nitrogen by cow.	Loss of nitrogen by cow.	Fat income.	Fat outgo.			Loss of fat by cow.
		Milk.	Urine.	Feces.	Total.				Milk.	Feces.	Total.	
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
Jan. 30 to 31........	282.1	80.9	80.8	81.7	243.4	38.7		126.5	614.8	87.3	702.1	575.6
Jan. 31 to Feb. 1....	284.5	79.8	84.0	93.2	257.0	27.5		128.1	603.1	100.7	703.8	575.7
Feb. 1 to 2........	280.9	82.5	77.2	88.2	247.9	33.0		125.6	583.7	97.8	681.5	555.9
Feb. 2 to 3........	282.1	81.5	90.3	96.4	268.2	13.9		126.8	524.4	93.8	618.2	491.4
Feb. 3 to 4........	282.1	83.2	97.0	100.2	280.4	1.7		125.6	521.7	100.2	621.9	496.3
Feb. 4 to 5........	283.3	81.0	87.6	105.1	273.7	9.6		125.6	533.3	112.0	645.3	519.7
Feb. 5 to 6........	284.5	83.2	92.4	108.9	284.5	—	—	124.4	622.4	110.5	732.9	608.5
Feb. 6 to 7........	282.1	81.9	80.4	90.8	253.1	29.0		126.8	621.2	96.3	717.5	590.7
Feb. 7 to 8........	283.3	82.2	85.4	89.3	256.9	26.4		128.1	545.9	98.4	644.3	516.2
Feb. 8 to 9........	283.3	79.1	95.3	88.8	263.2	20.1		126.8	518.2	93.1	611.3	484.5
Feb. 9 to 10........	284.5	81.1	89.5	107.7	278.3	6.2		126.8	522.3	109.2	631.5	504.7
Feb. 10 to 11........	283.3	80.8	77.1	107.1	265.0	18.3		125.6	498.1	105.2	603.3	477.7
Feb. 11 to 12........	284.5	79.6	94.4	91.6	265.6	18.9		128.1	461.8	83.6	545.4	417.3
Feb. 12 to 13........	284.5	84.7	91.3	87.0	263.0	21.5		126.8	531.4	81.9	613.3	486.5
Feb. 13 to 14........	280.2	80.2	86.0	105.7	271.9	8.3		128.0	512.2	97.5	609.7	481.7
Feb. 14 to 15........	279.4	82.8	96.0	88.3	267.1	12.3		127.8	580.6	79.5	660.1	532.3
Feb. 15 to 16........	277.5	81.8	79.1	114.1	275.0	2.5		127.7	592.8	105.9	698.7	571.0
Feb. 16 to 17........	274.3	78.1	92.8	89.7	260.6	13.7		126.3	588.8	90.6	679.4	553.1
Feb. 17 to 18........	266.2	78.3	86.2	105.5	270.0		3.8	126.1	563.2	104.9	668.1	542.0
Feb. 18 to 19........	269.3	77.9	88.4	94.9	261.2	8.1		127.8	583.8	89.6	673.4	545.6
Feb. 19 to 20........	268.9	78.0	89.7	104.7	272.4		3.5	127.2	513.5	97.5	611.0	483.8
Feb. 20 to 21........	263.2	79.4	84.4	96.9	260.7	2.5		128.4	544.7	89.4	634.1	505.7
Feb. 21 to 22........	261.2	77.3	76.7	98.1	252.1	9.1		128.2	526.9	95.2	622.1	493.9
Feb. 22 to 23........	255.6	77.6	77.0	110.0	264.6		9.0	128.0	519.5	101.2	620.7	492.7
Feb. 23 to 24........	256.2	77.4	80.7	100.2	258.3		2.1	127.9	536.8	97.6	634.4	506.5
Feb. 24 to 25........	251.8	74.0	71.8	99.3	245.1	6.7		126.4	464.4	98.7	563.1	436.7
Feb. 25 to 26........	245.0	77.3	71.4	96.3	245.0	—	—	126.4	517.1	96.0	613.1	486.7
Feb. 26 to 27........	243.0	78.8	66.1	98.3	243.2		.02	126.2	590.6	98.6	689.2	563.0

BALANCE SHEET OF NITROGEN AND FAT. (COW 12.)—*Continued.*

Date.	Nitrogen income.	Nitrogen outgo: Milk.	Nitrogen outgo: Urine.	Nitrogen outgo: Feces.	Nitrogen outgo: Total.	Gain of nitrogen by cow.	Loss of nitrogen by cow.	Fat income.	Fat outgo: Milk.	Fat outgo: Feces.	Fat outgo: Total.	Loss of fat by cow.
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
Feb. 27 to 28........	241.0	75.1	63.6	102.6	241.3		0.3	126.0	535.7	98.5	634.2	508.2
Feb. 28 to Mar. 1...	237.9	75.4	64.2	104.0	243.6		5.7	126.0	546.5	118.9	665.4	539.4
Mar. 1 to 2........	238.4	74.0	55.9	94.9	224.8	13.6		125.8	490.2	95.2	585.4	459.6
Mar. 2 to 3........	231.5	73.3	56.4	102.9	232.6		1.1	125.6	446.2	96.3	542.5	416.9
Mar. 3 to 4........	229.0	72.3	47.1	97.0	216.4	12.6		126.3	467.4	95.7	563.1	436.8
Mar. 4 to 5........	228.3	75.1	56.9	95.8	227.8	0.5		124.9	487.1	85.3	572.4	447.5
Mar. 5 to 6........	221.5	74.9	53.2	97.6	225.7		4.2	126.1	489.8	90.8	580.6	454.5
Mar. 6 to 7........	218.4	71.9	53.7	103.4	229.0		10.6	125.9	474.5	109.5	584.0	458.1
Mar. 7 to 8........	212.8	69.2	47.8	97.0	214.0		1.2	124.5	467.4	102.4	569.8	445.3
Mar. 8 to 9........	208.3	69.3	47.7	100.1	217.1		8.8	124.4	496.6	95.1	591.7	467.3
Mar. 9 to 10........	210.8	66.7	42.3	88.4	197.4	13.4		125.7	508.2	84.5	592.7	467.0
Mar. 10 to 11........	210.8	66.1	40.8	95.1	202.0	8.8		124.4	491.8	91.1	582.9	458.5
Mar. 11 to 12........	210.9	64.1	43.5	96.0	203.6	7.3		124.4	476.5	91.4	567.9	443.5
Mar. 12 to 13........	212.1	64.5	41.9	94.3	200.7	11.4		124.4	418.1	91.7	509.8	385.4
Mar. 13 to 14........	207.2	64.6	40.8	92.5	197.9	9.3		123.1	447.8	96.4	544.2	421.1
Mar. 14 to 15........	209.6	66.7	45.0	98.4	210.1		0.5	123.1	474.9	94.3	569.2	446.1
Mar. 15 to 16........	216.4	66.5	40.4	99.1	206.0	10.4		124.5	479.9	91.0	570.9	446.4
Mar. 16 to 17........	220.9	68.2	47.2	95.0	210.4	10.5		124.6	468.8	93.4	562.2	437.6
Mar. 17 to 18........	224.0	69.2	47.5	100.4	217.1	6.9		124.8	490.6	96.3	586.9	462.1
Mar. 18 to 19........	228.3	67.5	46.7	100.2	214.4	13.9		124.9	440.4	98.5	538.9	414.0
Mar. 19 to 20........	231.5	70.9	55.8	100.4	227.1	4.4		125.0	521.1	91.9	613.0	488.0
Mar. 20 to 21........	235.2	71.2	60.3	104.2	235.7		0.5	125.6	504.9	92.8	597.7	472.1
Mar. 21 to 22........	238.4	70.5	53.0	101.4	224.9	13.5		127.1	494.7	94.5	589.2	462.1
Mar. 22 to 23........	241.6	70.9	57.5	84.3	212.7	28.9		126.0	461.3	79.8	541.1	415.1
Mar. 23 to 24........	244.7	69.4	62.4	104.1	235.9	8.8		127.3	445.4	96.4	541.8	414.5
Mar. 24 to 25........	246.7	66.9	61.3	89.5	217.7	29.0		126.2	503.8	83.5	587.3	461.1
Mar. 25 to 26........	249.9	70.7	71.4	98.3	240.4	9.5		126.4	478.9	98.3	577.2	450.8
Mar. 26 to 27........	251.8	67.7	69.2	102.5	239.4	12.4		126.4	465.1	111.7	576.8	450.4

BALANCE SHEET OF NITROGEN AND FAT. (COW 12.)—*Concluded.*

DATE.	Nitrogen income.	Nitrogen outgo.				Gain of nitrogen by cow.	Loss of nitrogen by cow.	Fat income.	Fat outgo.			Loss of fat by cow.
		Milk.	Urine.	Feces.	Total.				Milk.	Feces.	Total.	
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
Mar. 27 to 28........	252.5	70.5	80.7	100.2	251.4	1.1		126.6	484.6	94.6	579.2	452.6
Mar. 28 to 29........	256.8	72.8	80.4	108.9	262.1		5.3	126.7	519.0	97.0	616.0	489.3
Mar. 29 to 30........	258.8	73.4	80.4	96.7	250.5	8.3		126.9	490.3	94.5	584.8	457.9
Mar. 30 to 31........	260.8	75.2	82.2	97.3	254.7	6.1		127.1	512.8	102.7	615.5	488.4
Mar. 31 to Apr. 1....	264.0	73.2	76.7	98.9	248.8	15.2		127.0	490.4	95.7	586.1	459.1
Apr. 1 to 2........	266.9	70.1	83.0	102.1	255.2	11.7		127.1	486.9	97.5	584.4	457.3
Apr. 2 to 3........	273.7	70.2	88.2	107.1	265.5	8.2		128.6	469.5	109.6	579.1	450.5
Apr. 3 to 4........	278.2	69.8	91.0	91.8	252.6	25.6		128.8	489.5	90.3	579.8	451.0
Apr. 4 to 5........	282.6	68.7	98.9	106.8	274.4	8.2		130.1	477.7	108.4	586.1	456.0
Apr. 5 to 6........	284.5	70.8	101.7	103.9	276.4	8.1		130.2	503.6	108.7	612.3	482.1
Apr. 6 to 7........	289.0	71.7	109.4	87.9	269.0	20.0		127.9	512.1	86.3	598.4	470.5
Apr. 7 to 8........	286.5	70.8	110.5	101.3	282.6	3.9		130.2	463.6	94.8	558.4	428.2
Apr. 8 to 9........	285.3	70.0	107.4	100.3	277.7	7.6		130.2	470.8	97.6	568.4	438.2
Apr. 9 to 10........	284.1	74.9	108.0	109.8	292.7		8.6	130.2	555.1	113.2	668.3	538.1
Apr. 10 to 11........	286.5	73.0	113.0	99.9	285.9	0.6		128.0	539.3	96.1	635.4	507.4
Apr. 11 to 12........	285.3	66.9	89.0	86.5	242.4	42.9		127.7	430.1	85.7	515.8	388.1
Apr. 12 to 13........	284.1	72.8	103.6	102.1	278.5	5.6		128.9	470.6	105.1	575.7	446.8
Apr. 13 to 14........	289.0	74.8	99.1	101.0	274.9	14.1		130.2	460.3	109.9	570.2	440.0
In grams............	18983.3	5482.8	5545.7	7279.9	18308.4	740.3	65.4	9375.8	37637.0	7165.1	44802.1	35426.0
In lbs...............	41.85	12.09	12.23	16.05	40.37	1.63	.14	20.67	82.98	15.80	98.77	78.10

BALANCE SHEET OF NITROGEN AND FAT. (COW 10.)

DATE.	Nitrogen income.	Nitrogen outgo.				Gain of nitrogen by cow.	Loss of nitrogen by cow.	Fat income.	Fat outgo.			Loss of fat by cow.	Gain of fat by cow.
		Milk.	Urine.	Feces.	Total.				Milk.	Feces.	Total.		
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
Jan. 30 to 31....	209.3	57.8	60.7	73.1	191.6	17.7		362.9	541.2	68.3	609.5	246.6	
Jan. 31 to Feb. 1	211.7	58.1	65.7	71.5	195.3	16.4		364.2	472.3	66.6	538.9	174.7	
Feb. 1 to 2....	208.1	60.2	61.9	74.5	196.6	11.5		361.7	545.0	68.5	613.5	251.8	
Feb. 2 to 3....	209.3	59.5	59.4	75.2	194.1	15.2		362.9	495.5	67.1	562.6	199.7	
Feb. 3 to 4....	209.3	60.8	59.0	78.8	198.6	10.7		361.7	415.9	69.1	485.0	123.3	
Feb. 4 to 5....	210.5	60.4	65.0	85.8	211.2		0.7	361.7	532.6	71.8	604.4	242.7	
Feb. 5 to 6....	211.7	61.7	58.8	81.6	202.1	9.6		362.9	447.5	76.8	524.3	161.4	
Feb. 6 to 7....	209.3	59.7	63.5	83.2	206.4	2.9		362.9	464.1	81.4	545.5	182.6	
Feb. 7 to 8....	210.5	61.8	63.8	76.8	202.4	8.1		364.2	527.1	76.6	603.7	239.5	
Feb. 8 to 9....	210.5	59.3	69.0	76.9	205.2	5.3		362.9	542.1	68.2	610.3	247.4	
Feb. 9 to 10....	211.7	57.3	64.2	89.9	211.4	0.3		362.9	469.9	78.9	548.8	185.9	
Feb. 10 to 11....	210.5	56.7	69.8	84.3	210.8		0.3	361.7	488.5	74.5	563.0	201.3	
Feb. 11 to 12....	211.7	56.9	64.4	79.1	200.4	11.3		364.2	466.0	63.2	529.2	165.0	
Feb. 12 to 13....	211.7	59.1	69.8	79.3	208.2	3.5		362.9	484.7	65.6	550.3	187.4	
Feb. 13 to 14....	210.5	58.4	67.0	81.4	206.8	3.7		364.2	475.7	69.4	545.1	180.9	
Feb. 14 to 15....	213.0	58.0	64.2	83.5	205.7	7.3		364.2	514.0	67.4	581.4	217.2	
Feb. 15 to 16....	214.2	58.8	53.4	90.4	202.6	11.6		364.2	460.4	88.9	549.3	185.1	
Feb. 16 to 17....	214.2	57.1	63.8	86.8	207.7	6.5		362.9	472.7	74.4	547.1	184.2	
Feb. 17 to 18....	209.3	60.2	69.8	88.5	218.5		9.2	362.9	499.9	79.4	579.3	216.4	
Feb. 18 to 19....	213.0	59.2	78.5	80.7	218.4		5.4	364.2	517.7	68.0	585.7	221.5	
Feb. 19 to 20....	213.0	59.5	75.4	89.5	224.4		11.4	362.9	504.6	68.7	573.3	210.4	
Feb. 20 to 21....	210.5	60.4	74.2	87.1	221.7		11.2	364.2	489.7	67.7	557.4	193.2	
Feb. 21 to 22....	211.7	59.2	64.3	92.8	216.3		4.6	364.2	458.2	73.2	531.4	167.2	
Feb. 22 to 23....	209.3	60.7	72.8	89.4	222.9		13.6	364.2	461.4	72.0	533.4	169.2	
Feb. 23 to 24....	213.0	60.4	62.8	86.4	209.6	3.4		364.2	492.4	71.1	563.5	199.3	
Feb. 24 to 25....	211.7	61.6	66.2	87.7	215.5		3.8	361.9	484.3	72.6	556.9	194.0	
Feb. 25 to 26....	208.1	62.5	61.0	91.6	215.1		7.0	362.9	477.4	75.5	552.9	190.0	
Feb. 26 to 27....	209.3	61.2	58.0	87.2	206.4	2.9		362.9	481.4	69.5	550.9	188.0	

BALANCE SHEET OF NITROGEN AND FAT. (COW 10.)—*Concluded.*

DATE.	Nitrogen income.	Nitrogen outgo.				Gain of nitrogen by cow.	Loss of nitrogen by cow.	Fat income.	Fat outgo.			Loss of fat by cow.	Gain of fat by cow.
		Milk.	Urine.	Feces.	Total.				Milk.	Feces.	Total.		
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
Feb. 27 to 28....	209.1	60.1	62.7	86.4	209.2		0.1	383.7	459.6	73.2	532.8	149.1	
Feb. 28 to Mar. 1	206.3	60.4	68.4	91.0	219.8		13.5	419.7	484.1	80.8	564.9	145.2	
Mar. 1 to 2....	207.2	58.8	64.2	85.3	208.3		1.1	455.8	470.7	75.0	545.7	89.9	
Mar. 2 to 3....	200.8	59.2	64.3	85.8	209.3		8.5	491.9	459.7	68.3	528.0	36.1	
Mar. 3 to 4....	199.3	61.0	72.8	86.7	220.5		21.2	529.2	525.8	68.6	594.4	65.2	
Mar. 4 to 5....	198.5	58.4	54.7	89.3	202.4		3.9	563.8	491.4	71.7	563.1		0.7
Mar. 5 to 6....	192.6	59.4	56.9	80.1	196.4		3.8	601.2	534.6	70.3	604.9	3.7	
Mar. 6 to 7....	189.9	58.7	48.8	83.4	190.9		1.0	637.2	518.5	82.4	600.9		36.3
Mar. 7 to 8....	187.4	57.2	52.5	87.3	197.0		9.6	635.9	520.2	77.7	597.9		38.0
Mar. 8 to 9....	186.1	59.1	50.7	81.3	191.1		5.0	635.9	506.7	75.1	581.8		54.1
Mar. 9 to 10....	188.6	59.4	54.1	84.1	197.6		9.0	637.2	530.1	72.3	602.4		34.8
Mar. 10 to 11....	188.6	58.6	50.1	84.0	192.7		4.1	635.9	534.5	73.4	607.9		28.0
Mar. 11 to 12....	192.3	59.4	45.4	81.9	186.7	5.6		637.2	476.9	69.7	546.6		90.6
Mar. 12 to 13....	193.5	59.6	49.4	84.3	193.3	0.2		637.2	506.9	69.3	576.2		61.0
In grams........	8646.8	2495.8	2621.4	3523.9	8641.1	153.7	148.	18072.5	20701.9	3042.2	23744.1	6015.1	343.5
In lbs...........	19.07	5.50	5.78	7.77	19.05	.34	.33	39.85	45.65	6.71	52.35	13.26	.76

BALANCE SHEET OF NITROGEN AND FAT. (COW 2.)

DATE.	Nitrogen income.	Nitrogen outgo.				Gain of nitrogen by cow.	Loss of nitrogen by cow.	Fat income.	Fat outgo.			Loss of fat by cow.
		Milk.	Urine.	Feces.	Total.				Milk.	Feces.	Total.	
	Grms.	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*	*Grms.*
April 14 to 15...........	302.0	87.3	77.2	89.5	254.0	48.0		401.4	845.9	7.5	853.4	452.0
April 15 to 16...........	294.7	86.3	100.7	97.2	284.2	10.5		369.2	823.6	8.0	831.6	462.4
April 16 to 17...........	298.3	84.6	89.3	98.2	272.1	26.2		380.1	761.8	7.9	769.7	289.6
April 17 to 18...........	300.1	84.3	102.2	88.1	274.6	25.5		383.2	857.2	6.7	863.9	480.7
In grams	1195.1	342.5	369.4	373.0	1084.9	110.2		1533.9	3288.5	30.1	3318.6	1784.7
In lbs..................	2.63	.75	.81	.82	2.39	.24		3.38	7.25	.07	7.32	3.93

The next table summarizes the results of the entire periods during which exact observations were made, and expresses numerically the necessary conclusions from these investigations as to the formation of milk fat.

RELATION OF MILK FAT TO FOOD FAT AND PROTEIN.

	Days of expt.	Fat digested from food. Lbs.	Theoretical fat from protein. Lbs.	Fat in milk. Lbs.	Fat not accounted for from food fat and protein. Lbs.	Gain in weight of cow.* Lbs.
Grade Jersey, fat-poor ration†	59	3.3	17.1	38.8	18.4	33
Cow 12, fat-poor ration	74	4.8	39.2	83	39	15
Cow 2, normal herd ration	4	3.37	2.61	7.23	1.25	—
Cow 10, fat-rich ration	42	33.1	18.5	45.5	—6.1	18

* Based upon average of ten days weighings.
† From Bul. 132, N. Y. Agl. Expt. Station.

Some of the figures given are based upon assumptions for which there is little or no justification, but which certainly safeguard drawing unwarranted conclusions as to the possible production of milk fat from carbohydrates.

It is assumed that the digested food fat (ether extract) may be the source of an equivalent quantity of milk fat, but when we consider that ether extract is not wholly fat or oil, and that the glycerides of milk differ widely in kinds and proportions from the fatty compounds of the plant, we see how unwarranted such an assumption is. Again, the fat factor of protein is taken as 51.4, this being the maximum proportion based upon a theoretical rearrangement of atoms, of the actual accomplishment of which we have no assurance. For these reasons the excess of milk fat as given, over and above that possibly derived from the food protein and fats, is quite probably considerably more than is stated. But even as the figures stand they are certainly convincing. It is not possible to avoid the conclusion that carbohydrates serve as at least a partial source of the milk fat.

With all four cows the ether extract was insufficient for supplying the milk fat to the extent of the following daily quantities, even allowing the absurd assumption that ether extract is all convertible into milk fat.

Grade Jersey, fat-poor ration	.60 lbs.
Cow 12, fat-poor ration	1.06 lbs.
Cow 2, normal herd ration	.96 lbs.
Cow 10, fat-rich ration	.30 lbs.

The milk fat could not come wholly from protein, taking the urine nitrogen to be the measure of the protein broken down, as we necessarily must. Neither could the combined effect of both food fat and decomposed protein account for all the milk fat, the deficit in the case of three cows being large.

We are now confined to the alternatives of concluding either that previously formed body fat was drawn upon to supply the milk fat or that the carbohydrates were utilized for this purpose. The increased weight of two of the cows, and their generally improved condition during the experiments, preclude the conclusion that 18.4 lbs. and 39 lbs., respectively, of pure fat could have been withdrawn from their bodies. Such a result would have produced a marked change in condition and an appreciable diminution of weight. The case of Cow 2 is especially noteworthy. This was an undersized cow, thin in flesh at the birth of her calf, whose butter fat yield before, during and after the experiment was above 12 lbs. per week, and it did not fall below 10 lbs. for some time, so that her butter production in a year was not less than 500 lbs. During her largest flow of milk at least one-sixth of her fat product could not have been supplied from the normal herd ration she was eating, without drawing upon the carbohydrates. To assume that her small store of previously acquired body fat was drawn upon to the extent of this deficit would be the height of absurdity. Cow 12, eating a fat-poor ration, produced 39 lbs. of milk fat more than the ration could supply independently of the carbohydrates, and to all appearances she could have kept on for a year secreting normal milk from the ration she received. May we not finally conclude, then, that carbohydrates may be a source of milk fat?

RELATION OF PROTEIN EXCHANGE TO MILK PRODUCTION.

The relation of protein metabolism to the production of milk is interesting and important. It is recognized, of course, that there is a positive demand for protein in the secretion of milk solids, and it is not difficult to calculate the probable extent of

this demand in a given case. For instance, during her maximum production the milk of Cow 12 contained about 1.12 lbs. of protein (N x 6.25) daily. The cow was eating each day 2.6 lbs. of digestible protein. The real question is, What is the function of the protein remaining after deducting the milk protein from the total amount eaten, or in this case, 1.48 lbs.? An examination of the figures for urine nitrogen shows that the larger part of this balance, or 1.2 lbs., was not stored but was broken down into simpler compounds and so destroyed. Does this metabolic change bear any fixed relation to the milk solids or milk fat secreted? The data of these experiments indicate a negative answer to this question.

RELATION OF PROTEIN EXCHANGE TO MILK PRODUCTION.

Days of periods.		Income digested nitrogen.	Urine nitrogen.	Milk nitrogen.	Milk solids.	Milk fat.	Nitrogen balance.	Milk solids for each gram urine nitrogen.	Milk fat for each gram urine nitrogen.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
	Grade Jersey:								
7......	Maximum protein supply......	134.6	62.3	43.2	1004.7	345.7	+29.2	16.1	5.5
7......	Protein supply depressed......	65.5	33.4	35.6	855.4	295.8	—3.5	25.6	8.8
8......	Protein supply increased......	114.6	44.6	37.2	890.2	304.4	+32.8	20	6.8
	Cow 12:								
10......	Maximum protein supply......	188.6	87	81.5	1975.9	568.9	+20	22.7	6.5
10......	Minimum protein supply......	117.1	43.7	66.6	1594.6	475.3	+6.9	36.5	10.9
10......	Maximum protein supply restored	185.7	104.1	71.4	1635.4	488.3	+10.2	15.7	4.7

The foregoing figures make it plain that the excess of digestible protein in the ration over and above that needed for the milk, rather than any demand for milk secretion, largely determines the extent to which protein suffers destructive changes. In the case of the grade Jersey the daily protein supply was gradually diminished from 1.8 lbs. to .9 lb. and with Cow 12 from 2.6 lbs. to 1.6 lbs. The most marked result was to depress the daily protein decomposition from .86 lb. to .46 lb. in one case and from 1.2 lbs. to .60 lb. in the other case. When the food protein was increased to the original quantity the reverse process took place. While the protein utilized for milk secretion was somewhat lessened when the food protein was decreased, the depression of milk yield was not at all commensurate with the drop in the digested protein. This accommodation of the cow's metabolic process to a diminished protein supply mostly by a decrease in protein decomposition rather than wholly by depressing the milk production, indicates what the writer has previously suggested, that protein exchange outside the formation of the nitrogen compounds of the milk has no constructive function and that so large a quantity of protein as 2.5 lbs. daily for the average cow is justified only on the theory that the balance above what is really utilized in the milk and what would be required for maintenance in a non-producing animal acts to stimulate milk secretion rather than to support it. These comments are not to be taken as implying that a liberal supply of protein is not promotive of generous milk secretion.

A view unsupported by valid evidence, which has been more or less current and has been to some extent accepted in a popular way, is that the fat supply in the food modifies butter fat formation to an important extent. It is already shown in the context that with Cow 10 a large increase in the food fat did not affect the proportion of fat in the milk or the amount secreted. No inquiry was made as to whether the constitution of the butter fat mixture was in any way affected.

ENERGY VALUES AND RELATIONS.

As before stated, the main object of these experiments was to study the food sources of milk fat. The complete record of the foods eaten, of the excreta and of the milk produced for so long a time, and the collection and preservation of samples of all of these, enabled us to study with advantage certain other questions related to animal nutrition. Attention was given chiefly to energy values and relations, although an unsuccessful attempt was made to study sulphur metabolism.

The plan of work was the usual one, and the only one possible without the aid of the respiration calorimeter, viz: the determination in a calorimeter (Berthelot-Atwater) of the heats of combustion of the foods, milk and excreta of two cows during several periods of time. The data thus secured have made possible a calculation of energy values and uses, the figures from which are not without interest.

Methods.—Daily samples of the fresh foods, excreta and milk were selected with great care. The samples of fresh foods and feces were dried down over steam coils at a temperature of about 60° C. The urine and milk samples to which formaldehyde had been added were stored in tightly closed fruit-jars, and in this condition remained apparently unchanged for a long time. The quantity of formaldehyde used was about 2 c.c. to one quart of liquid.

The calorimeter determinations were made in the usual way. The milk and urine were dried down in the capsules in which they were burned. The urine suffered more or less loss of nitrogen during the drying. Nitrogen determinations were made in samples of urine before and after dessication and the amount of nitrogen lost by drying was assumed to come wholly from urea. N lost x 5.343 Cal. would therefore be the loss of energy due to drying and the number of calories thus calculated was applied as a correction to the calorimeter determinations. With those samples of urine which had suffered no fermentative changes this correction was in many instances less than one small calorie per gram of urine and never much over two small calories.

Heat values.—Heat or energy values were determined for three periods with Cow 12 and for one period with Cow 10. The detailed data are voluminous and are not given in this connection. Great care has been given to the various calculations and confidence may be placed in the mathematical accuracy of the figures presented herewith.

The average heat values found for one gram of dry matter in the feeding stuffs are as follows:

HEAT VALUES OF FEEDING STUFFS.

Kind of material.	Calories per gram, dry matter.
Mixed hay	4.494
Alfalfa hay	4.477
Oat straw	4.480
Corn meal (3 samples)	4.427
Oats (2 samples)	4.505
Rice meal (4 samples)	4.400
Linseed meal	5.042
Flaxseed meal	6.539
Wheat gluten (2 samples)	5.773
Sugar beets (32 samples)	3.925

The quantities of nutrients, total, digestible and otherwise, fed to the two cows during several periods were as given below:

NUTRIENTS CONSUMED BY THE COWS.

ANIMAL AND PERIODS.	Total dry matter consumed. Grams.	Dry matter in the feces. Grams.	Total digestible dry matter. Grams.	Total digestible organic matter. Grams.	Total carbohydrates digested. Grams.
Cow 12.					
1st Period, Jan. 30 to Feb. 6, 7 days	90985.1	27698.6	63286.5	61699.8	53358.2
2d Period, Feb. 19 to 26, 7 days	92657.8	28528.1	64129.7	62324.5	55255.1
3d Period, Mar. 8 to 16, 8 days	105344.1	34509.2	70834.9	68721.1	62698.9
Cow 10.					
Feb. 4 to 14, 10 days	102388.5	28023.3	74365.2	71414.1	60445.7

The above quantities combined with the various calorimetric determinations form the main data from which the energy values and relations are calculated. It should be stated by way of explanation that the loss of energy from the escape of gases, chiefly methane (CH_4), is based upon the results of numerous

observations by Kellner.* He found the average loss of methane to be 4.2 grams per 100 grams of digested carbohydrates. As 1 gram of methane represents 13.246 Cal., this energy loss equals 55.633 Cal. for each 100 grams of digested carbohydrates.

The data showing the loss of energy in the urine present some interesting considerations. In the first place they add to the evidence already secured by Rubner, Henneberg, Kuhn and Kellner† that the old methods of calculating urine energy on the assumption that the nitrogen exists wholly as urea and that the amount of nitrogen multiplied by 5.343 Cal. repesents all the urine energy, is greatly in error. The figures which follow make it clear that the heat value of the urine solids may be several times that resulting from the old method of calculation.

ACTUAL HEAT VALUE OF URINE COMPARED WITH CALCULATED VALUE.

Cow 12.						Cow 10.	
First period.		Second period.		Third period.			
Energy as determined.	Calculated, N in urine × 5.343 Cal.	Energy as determined.	Calculated, N in urine × 5.343 Cal.	Energy as determined.	Calculated, N in urine × 5.343 Cal.	Energy as determined.	Calculated, N in urine × 5.343 Cal.
Cal.	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Cal.*
1585.6	438.6	1692.1	486.9			1486.3	352.8
1631.7	455.9	1616.3	458				
1544.6	419	1480.2	416.3			1435	344.6
1704.1	490.1	1541.1	417.9	1371.6	236.1	1418	346.2
1682.8	526.5			1300.5	227.4	1454.9	374.5
		1443.3	389.7	1294.6	221.4	1409.6	348.4
1801.2	501.5	1510.3	387.1	1327.3	244.2	1570	378.8
						1462	349.5
						1534.4	378.8
						1498.7	363.6

It appears that the actual heat value of the urine solids was from three to four times as large as the value calculated on the basis of nitrogen as urea. This is explained by the fact that a variety of solids exist in the urine, quite a percentage of which are not nitrogenous.

It is also evident from the succeeding figures that the heat value of urine bears no constant relation to its nitrogen content.

**Landw. Vers. Stat.*, 53: 420.

†See *Zeit. f. Biol.*, 21: 250. *Neue Beitrage*, &c., p. 119.
Landw. Vers. Stat., 44: 348. 404, 474, 529.
Ibid., 47: 283, 308.
Also Bul. 42, Pa. State College Expt. Sta., pp. 148–150.

RELATION OF NITROGEN OF URINE TO ITS HEAT VALUE.

No. of day in period.	Cow 12. First period. Nitrogen in urine daily.	Cow 12. First period. Heat value of urine.	Cow 12. First period. Heat value per gram of nitrogen.	Cow 12. Second period. Nitrogen in urine daily.	Cow 12. Second period. Heat value of urine.	Cow 12. Second period. Heat value per gram of nitrogen.	Cow 12. Third period. Nitrogen in urine daily.	Cow 12. Third period. Heat value of urine.	Cow 12. Third period. Heat value per gram of nitrogen.	Cow 10. *In urine daily. Nitrogen	Cow 10. Heat value of urine.	Cow 10. Heat value per gram of urine.
	Grams.	*Cal.*	*Cal.*	*Grams.*	*Cal.*	*Cal.*	*Grams.*	*Cal.*	*Cal.*	*Grams.*	*Cal.*	*Cal.*
1	80.8	1585.6	19.6	89.7	1692.1	18.9				65	1486.3	22.9
2	84	1631.7	19.4	84.4	1616.3	19.2				58.8	1256.2	21.4
3	77.2	1544.6	20	76.7	1480.2	19.3				63.5	1435	22.6
4	90.3	1704.1	18.9	77	1541.1	20	43.5	1371.6	31.5	63.8	1418	22.2
5	97.0	1682.8	17.3	80.7			41.9	1300.5	31	69.0	1454.9	21.1
6	87.6			71.8	1443.3	20.1	40.8	1294.6	31.7	64.2	1409.6	22
7	92.4	1801.2	19.6	71.4	1510.3	21.2	45	1327.3	29.5	69.8	1570	22.5
8										64.4	1462	22.7
9										69.8	1534.4	22
10										67	1498.7	22.4
Av			19.1			19.8			30.9			22.2

In Period 1 with Cow 12 the amount of digested protein was large, about 2.6 lbs. daily, and in Period 3 it was only 1.6 lbs. The decrease in ingested protein caused a marked decrease in urine nitrogen. In Period 1 the heat value of the urine was equal to 19.1 Cal. for each gram of nitrogen present, and in Period 3, 30.9 Cal. This simply means that the less the nitrogen compounds present, the larger the relative quantity of other substances. We must conclude, then, that the loss of energy in urine cannot be calculated from any constant factor but must be determined in every particular case.

HEAT ENERGY OF THE NUTRIENTS IN SEVERAL PERIODS.

Periods.	Total Calories in dry matter consumed.	Total Calories in dry matter of feces.	Total Calories in urine.	Calories in digestible matter.	Calories in digestible matter minus the heat value of the urine.	Calories in digestible matter minus heat value of urine and of methane lost.
Cow 12.						
1st Period, 7 days	396017.9	129879.6	11623.2	266138.3	254515.1	224829.3
2d Period, 7 days	399765.8	136032.9	10881.2	263642.9	252761.7	222024.4
3d Period, 8 days	450326.2	162177.0	10584.0	288149.2	277565.2	242683.3
Cow 10.						
Feb. 4-10, 10 days	448583.6	127231.3	14525.1	321352.3	306827.2	273199.8

We have now reached a point in the development of our data where we can see what they teach concerning the unit heat values of the nutrients utilized by these two animals. From the figures of the two preceding tables the unit values given in the succeeding table were calculated.

HEAT VALUES BASED ON A UNIT OF ONE GRAM.

	Heat value dry matter of ration.	Heat value dry matter feces.	Heat value digestible dry matter.	Heat value digestible organic matter.	Heat value digestible organic matter less heat value urine.	Heat value digestible organic matter less less heat values urine and methane.
Cow 12.	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Cal.*	*Cal.*
1st Period.	4.35	4.69	4.20	4.31	4.12	3.64
2d Period..	4.31	4.77	4.11	4.23	4.05	3.56
3d Period..	4.27	4.70	4.07	4.19	4.04	3.53
Cow 10	4.38	4.54	4.32	4.49	4.29	3.82
Average	4.33	4.67	4.17	4.30	4.12	3.64

It is noteworthy, as has been pointed out by other observers, that the dry matter of the feces has a unit heat value considerably larger than that of the total dry matter of the ration and consequently the heat value of the digested portion should not be assumed on the basis of the proportion of the dry matter digested.

In computing the energy value of rations it has been customary to use the figures proposed by Rubner for the several classes of, nutrients, viz.: Protein 4.1 Cal., carbohydrates 4.1 Cal. fats 9.3 Cal. It appears now that these unit values are, if anything, fully high enough for herbivora, even if no allowance is made for loss of methane. Let us compare the actual heat values of the digestible matter in the several periods with what the calculated values would be on the Rubner basis.

Cow 12.

First Period.

Protein	8161.3 grams x 4.1=	33,461.3 Cal.
Carbohydrates	52358.2 grams x 4.1=	218,768.6 Cal.
Fats	180.3 grams x 9.3=	1,676.8 Cal.
		253,906.7 Cal.
	As determined*	=254,515.1 Cal.

Second Period.

Protein	6852.5 grains x 4.1=	28,095.2 Cal.
Carbohydrates	55255.1 grams x 4.1=	226,545.9 Cal.
Fats	216.9 grams x 9.3=	2,017.2 Cal.
		256,658.3 Cal.
	As determined*	=252,701.7 Cal.

Third Period.

Potein	5763.7 grains x 4.1=	23,631.2 Cal.
Carbohydrates	62698.9 grains x 4.1=	258,065.5 Cal.
Fats	258.5 grains x 9.3=	2,404.0 Cal.
		284,100.7 Cal.
	As determined*	=277,565.0 Cal.

Cow 10.

Protein	8064.3 grams x 4.1=	33,063.6 Cal.
Carbohydrates	60445.7 grams x 4.1=	247,827.4 Cal.
Fats	2904.1 grams x 9.3=	27,008.1 Cal.
		307,899.1 Cal.
	As determined*	=306,827.2 Cal.

*No allowance for methane.

If no allowance is made for the energy loss in methane the Rubner unit values are not greatly larger than the average of these determinations. If, however, the loss from the escape of hydrocarbons is as large as that observed by Kellner and others then the available energy of the digestible organic matter was 3.64 Cal. per gram. Kellner found it to be 3.5 Cal. for the digestible organic matter of meadow hay, and Armsby, in determinations with steers, using timothy hay, found it to be 3.62 Cal.

THE DISTRIBUTION OF THE ENERGY OF A RATION.

It is interesting and instructive to note the distribution of the energy of a ration. It may be classified, first as available and non-available. The available energy is applied to the various uses of the animal and in the case of the milch cow is distributed among the milk solids, the work of milk production and maintenance needs.

These energy relations are best expressed in terms of percentages without repeating any previous figures.

DISTRIBUTION OF TOTAL ENERGY OF RATION.

			Cow 12. Per. 1.	Cow 12. Per. 2.	Cow 12. Per. 3.	Cow 10.
			Per ct.	Per ct.	Per ct.	Per ct.
Methane not considered.	Available energy		64.3	63.2	61.6	68.4
	Non-available energy.	Urine	2.9	2.7	2.4	3.2
		Feces	32.8	34.0	36.0	28.4
Assumed methane energy deducted.	Available energy		56.8	55.5	53.9	60.9
	Non-available energy.	Urine	2.9	2.7	2.4	3.2
		Methane.	7.5	7.7	7.7	7.5
		Feces	32.8	34.0	36.0	28.4

DISTRIBUTION OF AVAILABLE ENERGY.

	Total available energy used daily.*	Maintenance energy.† Calories daily.	Maintenance energy.† Per ct of total available energy.	Energy of milk solids. Calories daily.	Energy of milk solids. Per ct. of total available energy.	Energy balance. Calories daily.	Energy balance. Per ct. of total available energy.
Cow 12.	Cal.						
Period 1....	32118	13846	43.1	11176	34.8	7096	22.1
Period 2....	31718	13846	43.6	10169	32.1	7703	24.3
Period 3....	30335	13846	45.3	10547	30.4	5942	24.3
Cow 10.......	27320	10152	37.	8451	30.9	8717	32.1

* After allowing for loss of energy in methane.

† Calculated on basis of 13,000 Cal. for 500 kilo animal.

The foregoing figures are instructive in showing approximately how the energy of the rations was utilized by these two milch cows. After accounting for the energy of maintenance on the basis of the best known data, viz: 13,000 Calories for an animal weighing 500 kilos (1100 lbs.) and the energy of the milk solids, we have a balance amounting on the average to about one-quarter of the available energy of the ration. If the ration were diminished to the extent of this balance it would certainly result in a lessened milk yield, consequently we are justified in concluding that this balance has some necessary function or relation in milk secretion.

The most natural and logical conclusion is that in part at least it sustains the work of milk secretion, *i. e.*, the vital activity involved in the metabolic changes occurring in the milk glands or elsewhere in the formation of milk solids. There is, of course, more work demanded for mastication and digestion than is the case with the much smaller maintenance ration. Nevertheless it is fair to regard the milch cow as a working animal, not in the exercise of mechanical force but in the maintenance of manufacturing processes which are sustained by the application of the quiet energies of life.

THE IMMEDIATE EFFECT ON MILK PRODUCTION OF CHANGES IN THE RATION.*

W. P. WHEELER.

INTRODUCTORY NOTE BY THE DIRECTOR.

The data discussed in this bulletin were mostly secured under a former administration. They are not the result of feeding experiments logically planned for the study of rations, but were incidental to the extensive breed tests that were carried on for several years, and for this reason they cannot be made the basis of so extensive or so safe conclusions as to feeding questions as otherwise might be the case.

The tables which Mr. Wheeler presents from nearly one thousand feeding periods with different animals may seem to be duplications in some cases, as for instance V, IX, X of the tables as compared with XXVI, XXV and XXVII. It is to be noticed that these tables differ as to the number of periods included, which is due to the fact that in one set the selection of data was made with reference to the effect of varying the quantity of nutrients and in the other set with reference to the influence of varying the protein. It is gratifying to note, however, that different groups of periods, involving practically similar conditions, indicate essentially similar conclusions.

Those who may study this bulletin should keep clearly in mind that only the *immediate* and not the *permanent* effect of rations is considered. Moreover, there should be a proper reservation of judgment concerning data logically so imperfect. Nevertheless, in some particulars these records mean much more in a practical way than some offered to the public which involve the use of very few animals during only two or three feeding

*A reprint of Bulletin No. 210.

periods. The evidence presented concerning one point is fairly consistent and is important, viz.: that changes in the quantity of nutrients have greatly more influence on the milk yield than proportionally large changes in the amount of protein. These data offer strong evidence that if the available energy of the ration is sufficient and is kept at a uniform point, there may be quite a wide range in the nutritive ratio without materially affecting the milk flow. This emphasizes the necessity of uniform feeding and the importance of knowing to what extent changes in the materials of a ration cause changes in the nutrients actively available. The evidence relative to the protein supply at least suggests the practicability of successfully feeding dairy cows from a well selected list of crops grown on the farm.

W. H. JORDAN, *Director.*

SUMMARY.

The data published in this bulletin show the changes in milk production which have immediately followed changes in the composition of the ration fed to cows. The efficiency of different rations for sustaining milk production over long periods is not shown.

Several hundred individual records (981 in all) for limited periods covering different changes in the rations were selected from those kept for a dairy herd during several years. These were grouped in accordance with certain relations which they held to factors of the recognized feeding standards, and averages were made. The average data considered are those which relate to changes in the amount of total digestible organic matter or "total nutrients," the fuel value, the amount of protein, and the nutritive ratio. No rations that would appear in any respect radically deficient were fed.

TOTAL NUTRIENTS.

In general, the milk flow increased most or diminished least when the greatest increase of total nutrients was made without regard to moderate changes in protein content. The most rapid

shrinkage of milk flow generally occurred when the percentage reduction of total nutrients was greatest, although this usually was associated with a reduction of protein.

On the average for all records when an increase of the total nutrients was made, there was no change in milk production. On the average for all when the amount of nutrients was reduced, the shrinkage in milk flow was at twice the normal rate.

An increase in the amount of total nutrients to not more than 15.5 lbs. per day for each 1000 lbs. live weight, with cows giving about 20 lbs. of milk, resulted in a maintenance of the milk yield without diminution. When the nutrients were reduced in corresponding rations, more than the usual shrinkage followed.

An increase of the total nutrients from less than 15.5 lbs. to more than that amount, for cows giving about 23 lbs. of milk, resulted in a maintenance of milk yield without diminution. A reduction of the nutrients from above 15.5 lbs. to less than that amount was followed by twice the normal shrinkage in milk yield.

An increase of the total nutrients when above 15.5 lbs. for cows giving about 24 lbs. of milk, was followed by less than the usual shrinkage in milk flow. A reduction of the total nutrients to not less than 15.5 lbs. was followed by more than the usual shrinkage.

FUEL VALUE.

An average of all records when an increase in the fuel value of the ration was made shows a diminution in milk yield about one-fifth as great as would usually occur under unchanged rations. An average of all records when the fuel value was reduced shows about twice the usual diminution in milk yield.

An increase in the fuel value to not more than 30,000 Cal. per day per 1000 lbs. live weight, for cows giving about 20 lbs. of milk, was followed by a slight average increase in milk flow. A reduction of the fuel value when below 30,000 Cal. was followed by considerably more than the normal shrinkage in milk.

An increase in the fuel value from below 30,000 Cal. to more than that amount, for cows giving about 22 lbs. of milk, was followed by about the usual shrinkage in milk flow or less. A reduction of the fuel value from above to below 30,000 Cal. was followed by twice the usual shrinkage.

An increase in the fuel value when above 30,000 Cal., for cows giving about 24 lbs. of milk, resulted in a maintenance of the milk yield without shrinkage. A reduction of the fuel value to not less than 30,000 Cal., was followed by about twice the usual shrinkage in milk.

PROTEIN.

In general, changes in the amount of protein within ordinary limits produced less effect than changes in the amount of total nutrients. On the whole the diminution in milk flow was less when the amount of protein was increased than when it was reduced.

On the average for all records when the protein was increased, those including also an increase of total nutrients show no falling off in milk production, those with but little change in nutrients show a normal diminution or less, those with a reduction of nutrients show a shrinkage greater than usual. On the average for all records when the protein was reduced those with an increase of total nutrients show less than the usual decrease in milk production, those with but little change of nutrients show about the normal shrinkage, those with a reduction of nutrients show a falling off at twice the normal rate.

The average of those records where there was an increase of protein without change in amount of total nutrients shows an increased cost of production. There was no increase in the cost of production, on the average, when the protein was reduced without change in amount of nutrients.

A reduction in the amount of protein, when the ration contained less than 2 lbs. per day per 1000 lbs. live weight, was followed by about twice the usual shrinkage in milk flow. An increase in the amount of protein when less than 2 lbs. was, in general, followed by less than the usual shrinkage.

A reduction in the amount of protein when between 2 lbs. and 2.25 lbs. was followed by more than the usual shrinkage in milk flow. An increase of the protein when between 2 and 2.25 lbs. was followed, on the whole, by less than the usual shrinkage.

While reduction of the protein when between 2.25 lbs. and 2.5 lbs. was followed by excessive diminution in milk flow, there was an accompanying reduction of total nutrients which would largely account for it. An increase in the amount of protein when between 2.25 and 2.5 lbs. was followed by very much less than the usual shrinkage of milk.

A reduction in the amount of protein when above 2.5 lbs. was followed by favorable results on the average for 123 records. The natural shrinkage in milk flow was retarded. The cost of production was not affected. An increase of the protein when above 2.5 lbs. is shown by only a few records—in these, however, there followed twice the usual shrinkage in milk flow.

NUTRITIVE RATIO.

Changes in the nutritive ratio within the ordinary limits had considerably less influence on the milk flow than did changes in the amount of total nutrients. In general, however, a narrowing of the ratio had a favorable effect on milk production, while a widening of the ratio tended toward the reverse.

When but little change in the amount of total nutrients occurred, a narrowing of the ratio was followed by less than the usual decrease in milk yield and a widening of the ratio by more than the usual decrease.

With an increase in the amount of total nutrients a narrowing of the ratio was followed by an increase in milk yield. A widening of the ratio was followed by a decrease (to less than the usual extent) although the average increase of total nutrients was nearly a pound greater than when the ratio was narrowed.

With a reduction in the amount of total nutrients of 10 or 12 per ct., there followed about the same average shrinkage in milk flow whether the ratio was narrowed or widened.

When the nutritive ratio was narrowed but kept wider than 1:6, no change occurred in the average amount of digestible dry matter consumed for each pound of milk solids produced. When the ratio was made wider there was an increase (over 4 per ct.) in amount of digestible dry matter for each pound of milk solids.

When rations with a narrower ratio than 1:6 were made still narrower there was the same increase in the amount of digestible dry matter required for each pound of milk solids as when corresponding rations were made wider but kept narrower than 1:6.

It must be remembered that these summarized results apply only to the immediate effect on milk production of the specified changes in the ration. It is not unreasonable to assume, however, that those modifiations of the ration which at once lead to increase in milk flow point toward the composition of a ration adapted to more permanent advantage, and that those modifications which are immediately followed by diminished product point in the direction of a ration more likely to prove inefficient for extended periods.

INTRODUCTION.

In the feeding of milch cows as well as that of other animals many difficult problems are involved. The solution of most of these cannot be accomplished without numerous investigations and studies under specially arranged conditions where factors commonly uncontrolled can be directly accounted for and their value considered. Many years must necessarily elapse before much of the positive knowledge sought can be secured. This knowledge will come in time. But every day the animals must have food, and any information relating to the commonly practiced methods of feeding is worth considering. Any carefully collected data should, therefore, repay attention; though they may not light up certain of the complex problems of nutrition, and may show only in a circumstantial way relations between the milk and the food.

While the fixing of an absolute standard stated in the terms we now use is not possible, it is still probable that with wider

information the limitations of the average physiological standard can be made more definite. All records of production under rations constructed in conformity with standard requirements should furnish information of more or less value. The results of departure, on one side or the other of the path marked out, should be worth recording.

The data published in this bulletin show changes in milk production which have immediately followed changes in the composition of the ration. Some changes in the ration appear to have no immediate effect on milk production. Others apparently have in a moderate degree either stimulating or depressing effects.

For many years rations conforming to certain limitations have been recommended by different investigators. The most convenient and practicable way of stating the food requirements of the animal in a concise and general manner has been in terms of digestible nutrients. As ordinarily grouped, these are protein, carbohydrates and fat. The total digestible organic matter is stated as well as the total dry matter. Water is taken for granted, and the mineral nutrients, although important, are not considered because the foods naturally available for supplying other nutrients would contain abundant ash.

In formulating a feeding standard for cows considerable difference of opinion exists as to the limits of variation, both in bulk and composition, that can be made without appreciable influence on production. The standard rations usually recommended for milch cows of average capacity require, for 1000 lbs. live weight:

From 27	to 29	lbs. of total dry matter,
From 13.4	to 16	lbs. of didgestible organic matter,
From 2	to 2.5	lbs. of digestible protein,
From 11	to 13	lbs. of digestible carbohydrates,
From .4	to .5	lb. of digestible fats;

with a nutritive ratio of from 1:6 to 1:5.7. For cows not approximating 1000 lbs. in weight, for cows of inferior capacity or for very heavy milkers, the standard is modified. The standard

which has been longest used as a general guide gives for the average cow in milk, per 1000 lbs. live weight

24 lbs. total organic matter,
15.4 lbs. total digestible organic matter,
2.5 lbs. total digestible protein,
12.5 lbs. total digestible carbohydrates;

with a nutritive ratio of about 1:5.4 and a fuel value of about 30,000 Calories.

These standards have been in large part drawn from averages. Slight individual modifications have therefore been occasionally desirable or without disadvantage. In practice, of course a close conformity may often be unprofitable because of relative market prices. The efficiency, however, of the modified standard ration is the point for first consideration.

While the results of only a few weeks under a ration will not show its permanent sustaining power, they may perhaps suggest the stimulating effects. To these are often attributed results not fully explained by the known utilization of nutrients in the product and the work of its construction. It is thought that the presence of a supply of protein considerably in excess of the indispensable amount which can be directly accounted for, tends to stimulate milk production.

In feeding a dairy herd at this Station during several years the common standards were followed in a general way. From the daily records of this herd are drawn the data before referred to. They represent both winter and summer feeding at different times during seven years. Individual records were kept of the food consumed, the changes in live weight and the milk yield. Analyses were made of the foods and of the milk at regular intervals so that the amounts of the different constituents in the food and in the milk have been calculated for each cow and averages made from these data. The records for short periods selected for use in these averages were taken at that stage of lactation when only very moderate changes in the milk flow might be expected. Of these limited-period, individual records, 981 have been used in making the averages considered here. When grouped according

to the same foods they form 111 groups with an average of nine cows each.

The food was changed often but no violent changes were made nor any rations fed that would appear in any respect radically deficient, as the primary object for keeping the herd would not have been furthered by the use of questionable rations. The change usually was only a substitution of one coarse fodder for another accompanied by a modification of the mixed grain. No unpalatable food was used. A moderate proportion of grain was always fed, varying from 5 to 9 lbs. per day, but generally about 7 lbs., the average for all the time being 6.63 lbs. per day. As a rule either silage, roots or green forage was fed with any hay or other dried fodder. Only 15 rations out of a thousand were without some succulent food, the average moisture content of these being 12.2 per ct. The average percentage of moisture in all the rations was 61 per ct.

Besides mixed grain, which was always fed, 336 rations consisted of silage and hay, 266 rations of green forage and hay, 76 rations of roots and hay; 72 rations contained two kinds of green forage and 47 rations one kind; 56 rations contained silage and green forage; 43 rations silage, hay and corn stover; 30 rations silage, forage and hay; 22 rations silage and corn stover; 15 rations hay alone; 10 rations silage, roots and hay, and 8 rations silage alone.

The coarse foods principally used were clover hay, timothy hay, mixed hay, corn silage, alfalfa forage, oat-and-pea forage, corn forage and mangels. Others sometimes fed were oat-and-pea hay, orchard-grass hay, corn stover, barley-and-pea forage, sorghum forage, rye forage, rye-and-pea forage, timothy forage, clover silage, sugar beets and carrots. The grain foods most commonly used were wheat bran, corn meal, ground oats, wheat middlings, old process linseed meal, cottonseed meal, different gluten meals and gluten feed. Others occasionally used were new process linseed meal, brewers' grains, ground flaxseed, buckwheat middlings and malt sprouts. In a grain mixture three kinds of ground feed were always used and generally more.

Special analyses were made of all the foods. The coefficients of digestibility used in the calculations were the averages from American determinations when several were to be found, but many of them were from European data. These calculations were made several years ago when factors from recent investigations were not available. The coefficients used differ somewhat from the latest averages but not enough to have a recalculation affect the general results. In Table A are given those used for the several foods.

Selecting records from a system of feeding conforming to other purposes did not permit an absolute uniformity in all relations essential to a direct and unqualified comparison of the different rations. The averaged groupings are therefore not by any means satisfactorily complete and full, although the volume of testimony in a degree compensates for some of the lack of uniformity. While a large number of records may cover one change in a ration, there may be comparatively few that afford data concerning some corresponding change, desired for comparison, so that in this respect also undesirable irregularity exists. Evidence only of the immediate, or perhaps stimulating, effect of the modified rations is offered. There is taken into consideration no intermediate period to permit full adjustment to the changed food, and the efficiency of the different rations for sustained milk production over longer periods is not shown. The record is taken for from two to four weeks before a change in a ration and for about the same time immediately following.

TABLE A.—AVERAGE COEFFICIENTS OF DIGESTIBILITY.

	Protein.	Fiber.	N. free extract.	Fats (ether extract).
Wheat bran	78.	33.	72.	76.
Cornmeal	76.	58.	87.	92.
Ground oats	78.	26.	77.	84.
Wheat middlings	82.	33.	88.	85.
O. P. linseed meal	86.	50.	80.	90.
Cottonseed meal	89.	33.	68.	95.
Gluten meal	87.	33.	91.	88.
Gluten feed	86.	34.	92.	82.
N. P. linseed meal	87.	61.	86.	91.
Brewers' grains	71.	46.	55.	86.

	Protein.	Fiber.	N. free extract.	Fats (ether extract).
Ground flaxseed	91.	60.	55.	86.
Buckwheat middlings	78.	35.	75.	85.
Malt sprouts	83.	41.	67.	90.
Clover hay	58.	54.	64.	55.
Timothy hay	49.	53.	63.	57.
Mixed hay	42.	49.	57.	54.
Corn silage	57.	69.	75.	84.
Alfalfa forage	67.	53.	78.	64.
Oat-and-pea forage	78.	57.	65.	71.
Corn forage	52.	52.	75.	77.
Mangels	83.	71.	95.	50.
Orchard-grass hay	59.	60.	55.	54.
Oat-and-pea hay	81.	57.	66.	74.
Corn stover	36.	64.	58.	70.
Sorghum forage	47.	59.	74.	74.
Rye forage	74.	83.	73.	67.
Clover silage	48.	60.	70.	67.
Beets and carrots	81.	80.	95.	77.

As a basis for comparison, the normal rate of shrinkage in milk flow that would usually occur under an efficient average unchanged ration was assumed to be, for every period of one-half month, about 2 per ct. during the third month of lactation, about 2.5 per ct. during the fourth and fifth months, about 3 per ct. during the sixth and seventh months, about 3.5 per ct. during the eighth month and about 4 per ct. during the ninth and tenth months. In making this estimate, data from this Station were considered in connection with some from the Cornell Experiment Station, and some records published a number of years ago by Dr. Sturtevant.

The amount fed was always about all that could apparently be used by the animal. As a rule there was a gain in live weight which indicates a usually sufficient amount of food. The cows were mostly of medium size and less than 1,000 lbs. in weight. The average weight per cow for all periods was 932 lbs.

An idea of the prevailing composition of the rations and of their efficiency is given by the following data: Under 1 is the average from 90 individual records for one month with rations having a fuel value of considerably less than 30,000 Cal., and supplying less than 15.5 lbs. of total digestible organic matter.

Under 2 is the average from 80 individual records for one month with rations having a fuel value considerably higher than 30,000 Cal., and supplying considerably more than 15.5 lbs. of total digestible organic matter.

TABLE B.—AVERAGES FROM RECORDS FOR ONE MONTH.

	1	2
Average age of cows, years	4	5.6
Average live weight per cow, pounds	894	967
Average month of lactation	6.2	4.5
Average gain in live weight for month, pounds	12	25
Fuel value of ration per 1000 lbs. live weight, Cal.	28,855	33,937
Total digestible organic nutrients per 1000 lbs. live weight pounds	14.6	17.0
Digestible protein per 100 lbs. live weight, pounds	2.1	2.3
Nutritive ratio	1:6.6	1:7.2
Milk yield, average per day per cow, pounds	20.2	25.9
Total solids in milk, average per day per cow, pounds	2.8	3.4
Percentage of fat in milk	4.4	4.0
Digestible dry matter in food for one pound of milk solids produced, pounds	4.6	4.8

As the great mass of individual data is of no general interest, only the averages from different groupings are given. The cost of production is usually stated. While the more nitrogenous foods, especially grain foods, are usually higher priced, the liberal use of such foods as alfalfa forage, oat-and-pea forage, clover hay, etc., has somewhat modified this relation. The cost relation is an uncertain and fluctuating one, of course, but the prices assumed for calculation would fairly represent the average cost of foods supplying rations of the stated composition. Hay was rated at $10 per ton, and corn stover at $5, silage and roots were rated at $3, green fodders at $2. Corn meal, wheat middlings and brewers' grains were rated at $20 per ton, wheat bran, malt sprouts and gluten feed at $18, ground oats, gluten meal and new process linseed meal at $25, old process linseed meal at $27, cottonseed meal at $30, and ground flaxseed, but little used, $60 per ton. The average food cost of milk for all the records considered was 73 cents per 100 lbs.

TOTAL ORGANIC NUTRIENTS.

Groupings of the different records according to the amount of the total digestible organic matter are first considered. The term "total nutrients" or "nutrients," whenever used without qualification in the text or tables, refers to the total digestible organic matter of the feeding standards without reference to the mineral matter. The term "dry matter," however, includes the ash.

CHANGE IN RATIONS WITHOUT CHANGE IN NUTRIENTS.

The average from 126 individual records in which very little change was made in the amount of nutrients—no change on the average—shows just about the shrinkage in milk flow that would normally occur at this stage of lactation. The average month of lactation was 6.2 and the average age of the cows 4.8 years. There was a moderate gain in weight, the rate tending to increase after the change of ration.

TABLE I.—A CHANGE IN RATION BUT NOT IN AMOUNT OF TOTAL NUTRIENTS.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 126 records from cows averaging 4.8 yrs. old and 6.2 months in milk.	For about 16 days before change and 17 days after.	Before	15.0	2.06	30,030	1:7.2	21.1	.90
		After	15.0	1.98	30,135	1:7.5	20.5	.86

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 126 records from cows averaging 4.8 yrs. old and 6.2 months in milk.	For about 16 days before change and 17 days after.	Before	4.2	.73	1.0	7.6	4.9
		After	4.2	.72	1.0	7.8	5.2

INCREASING THE AMOUNT OF NUTRIENTS.

The average from 268 records when the amount of total nutrients in the ration was increased shows no shrinkage in milk yield following the change. The relative increase of protein in the ration was much less than that of the total nutrients. The average month of lactation was 5.1 and the average age about 4.7 years. The gain in weight was very slow before the change and averaged over one-half pound per day afterward.

TABLE II.—AN INCREASE IN THE AMOUNT OF TOTAL NUTRIENTS.

			Per 1000 lbs. live weight.				Average per day per cow.	
			Total digestible organic matter.	Digestible protein	Fuel value	Nutritive ratio.	Milk yield.	Fat in milk.
Average of 268 records from cows averaging 4.7 yrs. old and 5.1 months in milk.	For about 18 days before change and 18 days after.		*Lbs.*	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
		Before	14.4	2.19	28,618	1:6.4	22.0	.89
		After	16.1	2.29	32,297	1:6.8	22.0	.89

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
Average of 268 records from cows averaging 4.7 yrs. old and 5.1 months in milk.	For about 18 days before change and 18 days after.		*Per ct.*	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
		Before	4.0	.71	1.0	7.1	4.6
		After	4.0	.72	1.0	7.8	5.1

REDUCING THE AMOUNT OF NUTRIENTS.

The average from 263 records when there was a reduction of the amount of total nutrients shows a shrinkage in the milk flow twice as great as would generally occur during the same time at this stage of lactation without change in the ration. The average reduction in the amount of protein was slight. The average month of lactation was 5.7 months and the average age 4.9 years. The gain in live weight, which was at the rate of

over one-half pound per day, was reduced to about one-third as much after the change in the ration.

TABLE III.—A REDUCTION IN THE AMOUNT OF TOTAL NUTRIENTS.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 263 records from cows averaging 4.9 yrs. old and 5 7 months in milk.	For about 18 days before change and 18 days after.	Before	16.2	2.23	32,320	1:7.0	22.0	.91
		After	14.6	2.18	29,075	1:6.5	20.8	.87

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 263 records from cows averaging 4.9 yrs. old and 5 7 months in milk.	For about 18 days before change and 18 days after.	Before	4.1	.72	1.0	7.9	5.2
		After	4.2	.75	1.0	7.5	5.0

THE AMOUNT OF TOTAL NUTRIENTS AND OF PROTEIN BUT LITTLE CHANGED.

On the average for 39 records, in each of which but little change in the amount of total nutrients and of the protein was made, there was slightly less than the usual shrinkage of the milk yield. There was a moderate rate of gain in weight before and after the change of ration.

TABLE IV.—LITTLE CHANGE IN THE AMOUNT OF NUTRIENTS OR OF THE PROTEIN.

			PER 1000 LBS. LIVE WEIGHT.				AVERAGE PER DAY PER COW.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs*
Average of 39 records from cows averaging 4.2 yrs. old and 6.2 months in milk.	For about 19 days before change and 21 days after.	Before	14.8	1.97	28,864	1:7.3	19.8	.88
		After	14.8	1.93	28,885	1:7.4	19.5	.86

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 39 records from cows averaging 4.2 yrs. old and 6.2 months in milk.	For about 19 days before change and 21 days after.	Before	4.4	.84	1.1	7.8	5.1
		After	4.4	.85	1.1	7.8	5.1

THE AMOUNT OF TOTAL NUTRIENTS BUT LITTLE CHANGED AND THE PROTEIN INCREASED.

The average of 44 records when, without change in the amount of nutrients, the protein was increased, shows about the normal diminution of the milk flow. There was moderate gain in weight, somewhat more rapid after the change of ration.

TABLE V.—LITTLE CHANGE IN THE AMOUNT OF NUTRIENTS WITH AN INCREASE OF PROTEIN.

			Per 1000 lbs. live weight.				Average per day per cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 44 records from cows averaging 5 yrs. old and 5.7 months in milk.	For about 15 days before change and 14 days after.	Before	14.8	1.86	29,927	1:7.8	22.3	.95
		After	14.7	2.16	30,034	1:6.8	21.8	.89

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 44 records from cows averaging 5 yrs. old and 5.7 months in milk.	For about 15 days before change and 14 days after.	Before	4.2	.65	.9	7.0	4.6
		After	4.1	.65	.9	7.6	5.0

THE AMOUNT OF NUTRIENTS BUT LITTLE CHANGED AND THE PROTEIN REDUCED.

The average of 43 records when the protein was reduced without change in the amount of nutrients shows considerably more than the usual shrinkage in milk flow. The moderate rate of gain in live weight was considerably increased after the change in the ration.

TABLE VI.—LITTLE CHANGE IN AMOUNT OF NUTRIENTS, WITH A REDUCTION OF PROTEIN.

			Per 1000 lbs. live weight.				Average per day per cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 43 records from cows averaging 5 yrs. old and 6.8 months in milk.	For about 14 days before change and 18 days after.	Before	15.5	2.33	31,193	1 :6.6	21.1	.86
		After	15.5	1.83	31,372	1 :8.4	20.1	.83

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 43 records from cows averaging 5 yrs. old and 6.8 months in milk.	For about 14 days before change and 18 days after.	Before	4.1	.70	1.1	7.9	5.2
		After	4.1	.69	1.1	8.0	5.5

THE AMOUNT OF NUTRIENTS BUT LITTLE CHANGED WHEN ABOVE 15.5 LBS.

By grouping without regard to the amount of protein those records in which the amount of nutrients, when above 15.5 lbs. per 1000 lbs. live weight, was but little changed, the following data are found. There was, in a majority of cases and on the average, considerable reduction in the amount of protein. The diminution in milk flow was at about twice the usual rate. The gain in live weight was considerably greater after the change than before.

TABLE VII.—THE AMOUNT OF NUTRIENTS ABOVE 15.5 LBS. BUT LITTLE CHANGED.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs*
Average of 42 records from cows averaging 5.9 yrs old and 6.4 months in milk.	For about 15 days before change and 18 days after.	Before	15.8	2.07	31,945	1 :7.6	23.0	.96
		After	15.6	1.84	31,988	1 :8.5	21.8	.93

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 42 records from cows averaging 5.9 yrs old and 6.4 months in milk.	For about 15 days before change and 18 days after.	Before	4.2	.68	1.0	7.6	5.1
		After	4.2	.66	1.0	7.7	5.4

THE AMOUNT OF NUTRIENTS BUT LITTLE CHANGED WHEN BELOW 15.5 LBS.

The average for 84 records when the amount of nutrients, less than 15.5 lbs. per day per 1000 lbs. live weight, was but little changed, gives the data in the following table. There was no change, on the average, in the amount of protein. The shrinkage in milk flow was considerably less than usually occurs. There was the same moderate rate of gain in live weight before and after the change of ration.

TABLE VIII.—THE AMOUNT OF NUTRIENTS BELOW 15.5 LBS. BUT LITTLE CHANGED.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 84 records from cows averaging 4.2 yrs. old and 6.1 months in milk.	For about 17 days before change and 17 days after.	Before	14.6	2.05	29,072	1:7.0	20.2	.87
		After	14.7	2.04	29,209	1:7.0	19.9	.83

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 84 records from cows averaging 4.2 yrs. old and 6.1 months in milk.	For about 17 days before change and 17 days after.	Before	4.3	.75	1.0	7.5	4.9
		After	4.2	.75	1.0	7.7	5.1

AN INCREASE IN THE AMOUNT OF NUTRIENTS WITH BUT LITTLE CHANGE IN PROTEIN.

The average of 73 records which cover periods when this change in the ration was made is shown in the following table. No shrinkage in milk flow followed, on the average, but instead a very slight increase. There was a little loss in live weight before the change and a good average rate of gain afterward.

TABLE IX.—THE AMOUNT OF TOTAL NUTRIENTS INCREASED, WITH LITTLE CHANGE OF PROTEIN.

			PER 1000 LBS. LIVE WEIGHT.				AVERAGE PER DAY PER COW.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 73 records from cows averaging 4.7 yrs. old and 4.6 months in milk.	For about 19 days before change and 17 days after.	Before	13.9	2.04	27,985	1:6.4	22.2	.91
		After	15.9	2.06	32,575	1:7.7	22.3	.90

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 73 records from cows averaging 4.7 yrs. old and 4.6 months in milk.	For about 19 days before change and 17 days after.	Before	4.1	.70	.8	6.5	4.3
		After	4.0	.72	1.0	7.5	4.9

AN INCREASE IN AMOUNT OF NUTRIENTS AND ALSO OF THE PROTEIN.

The average from 132 records, each of which covers periods when this change in the ration was made, gives the data of the following table. Less than the usual diminution in milk flow followed the change. There was but a very moderate increase in live weight under either ration.

TABLE X.—THE AMOUNT OF TOTAL NUTRIENTS INCREASED AND ALSO THE PROTEIN.

			Per 1000 lbs. live weight.				Average per day per cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
Average of 132 records from cows averaging 4.6 yrs. old and 4.9 months in milk.	For about 17 days before change and 19 days after.		*Lbs.*	*Lbs.*	*Cal*		*Lbs.*	*Lbs.*
		Before	14.5	2.03	28,633	1:6.9	22.4	.90
		After	16.0	2.44	31,863	1:7.0	22.1	.89
			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb of milk solids.	
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*	
		Before	4.0	.70	.9	7.1	4.5	
		After	4.0	.71	1.0	7.8	5.1	

AN INCREASE IN THE AMOUNT OF NUTRIENTS WITH A REDUCTON OF THE PROTEIN.

The average of 63 records when this change in the ration occurred shows no shrinkage in the milk flow but a very slight increase. There was an average gain in weight of about one pound per day after the change, about twice as much as preceded it.

TABLE XI.—THE AMOUNT OF TOTAL NUTRIENTS INCREASED AND THE PROTEIN REDUCED.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
Average of 63 records from cows averaging 5 yrs. old and 5.9 months in milk.	For about 18 days before change and 15 days after.		*Lbs.*	*Lbs.*	*Cal.*		*Lbs.*	*Lbs*
		Before	14.7	2.68	29,318	1:5.2	21.1	.86
		After	16.5	2.22	32,882	1:7.0	21.2	.88

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
Average of 63 records from cows averaging 5 yrs. old and 5.9 months in milk.	For about 18 days before change and 15 days after.		*Per ct.*	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
		Before	4.1	.72	1.0	7.8	5.0
		After	4.2	.74	1.1	8.4	5.5

AN INCREASE IN AMOUNT OF NUTRIENTS TO NOT MORE THAN 15.5 LBS.

The average of 111 records, in each of which there was an increase in the amount of nutrients to not exceeding 15.5 lbs. per day per 1000 lbs. live weight, is shown in the following table. The average increase in nutrients was slight but the usual shrinkage in milk flow did not occur. In 61 instances there was a decided increase of protein in the ration, in 24 instances a decided reduction and in 26 instances little change. There was but slight average gain in live weight.

With but little change in amount of protein.—The average of the 26 records in which little change in the amount of protein occurred shows a trifle less than the usual diminution of milk yield expected at this stage of lactation. The average increase in amount of nutrients was but little. A slight loss in live weight occurred. See A in Table XII.

With an increase in the amount of protein.—Sixty-one records show a slightly greater average yield of milk following the mod-

TABLE XII.—THE AMOUNT OF TOTAL NUTRIENTS INCREASED TO NOT MORE THAN 15.5 LBS.

		Per 1000 lbs. live weight.				Average per day per cow.						
		Total digestible organic matter. *Lbs.*	Digestible protein. *Lbs.*	Fuel value. *Cal.*	Nutritive ratio.	Milk yield. *Lbs.*	Fat in milk. *Lbs.*	Fat in milk. *Per ct.*	Approximate cost of food for one lb. of milk. *Cts.*	Dry matter in food for one lb. of milk. *Lbs.*	Dry matter in food for one lb. of milk solids. *Lbs.*	Digestible dry matter in food for each lb. of milk solids. *Lbs.*
Average of 111 records from cows averaging 4 yrs. old and 5.3 months in milk.	Before	13.7	2.06	27,325	1:6.5	19.9	.83	4.2	.73	1.0	7.3	4.7
	After	14.5	2.17	28,923	1:6.5	19.9	.81	4.1	.75	1.0	7.7	4.9
A — Average of 26 records from cows averaging 3.9 yrs. old and 3.6 months in milk.	Before	13.3	1.83	26,718	1:6.8	22.0	.94	4.3	.66	.8	6.4	4.1
	After	14.0	1.76	28,047	1:7.8	21.6	.89	4.1	.71	.9	6.7	4.4
B — Average of 61 records from cows averaging 3.8 yrs. old and 5.9 months in milk.	Before	13.9	1.94	27,794	1:7.1	19.5	.79	4.0	.72	1.0	7.3	4.7
	After	14.8	2.38	29,557	1:5.9	19.7	.79	4.0	.73	1.0	7.8	5.0
C — Average of 24 records from cows averaging 4.9 yrs. old and 6.8 months in milk.	Before	13.6	2.61	26,793	1:4.6	18.5	.82	4.4	.81	1.2	8.2	5.2
	After	14.2	2.09	28,259	1:6.5	18.4	.80	4.3	.85	1.2	8.4	5.5

erate increase of the total nutrients and more pronounced increase of protein. There was practically no change in live weight on the average. See B. Table XII.

With reduction of the protein.—In C, Table XII, are the data from the 24 records when with a little increase of the total nutrients there was considerable reduction of the protein. But very slight shrinkage in the milk flow occurred. There was a moderate rate of gain in weight before the change and a more rapid one afterward.

AN INCREASE OF TOTAL NUTRIENTS FROM LESS THAN 15.5 LBS. TO MORE THAN 15.5 LBS.

In the following table are the average data from 116 records when this increase in the ration was made. The average milk yield suffered none of the usual diminution. There was a slight average loss in live weight before the change of ration and a gain of over one pound per day per cow afterward.

With but little change in amount of protein.—The average of 47 records when with the above increase of nutrients there was but little change in protein is shown in A of Table XIII. Considerable increase in milk yield followed. There was considerable loss in live weight before the change and an average gain of about two pounds per day afterward.

With an increase of the protein.—The average data from 43 records are given in B of the same table. In each of these there was an increase in the amount of protein averaging about 20 per ct. The shrinkage in milk flow slightly exceeded the normal rate. There was a loss in live weight before the change of ration and a good rate of grain afterward.

With a reduction of the protein.—The average of 26 records in each of which the amount of protein was reduced is given in C of the table. While the amount of digestible protein per day was reduced about one-half pound, the average amount did not fall below $2\frac{1}{4}$ lbs. An increase in milk flow followed the change and but slight increase in the cost of production. There was a good rate of gain in live weight.

TABLE XIII.—THE TOTAL NUTRIENTS INCREASED FROM LESS THAN 15.5 LBS. TO MORE THAN 15.5 LBS.

		Per 1000 lbs. live weight.				Average per day per cow.						
		Total digestible organic matter	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb of milk solids
		Lbs.	Lbs.	Cal.		Lbs.	Lbs.	Per ct.	Cts	Lbs.	Lbs.	Lbs.
Average of 116 records from cows averaging 5 yrs. old and 5.1 months in milk.	Before	14.5	2.25	28,754	1:6.2	23.0	.92	4.0	.72	.9	6.8	4.5
	After	17.1	2.33	34,727	1:7.2	23.0	.93	4.0	.74	1.0	7.9	5.3
A Average of 47 records from cows averaging 5.1 yrs. old and 5.4 months in milk.	Before	14.3	2.16	28,685	1:6.2	22.2	.90	4.1	.72	.9	6.5	4.4
	After	17.0	2.23	35,080	1:7.6	22.7	.91	4.0	.72	1.0	7.9	5.2
B Average of 43 records from cows averaging 5.2 yrs. old and 4.3 months in milk.	Before	14.4	2.06	28,166	1:6.8	24.5	.98	4.0	.73	.9	6.6	4.3
	After	16.9	2.47	33,742	1:8.9	23.7	.96	4.1	.76	1.0	7.6	5.2
C Average of 26 records from cows averaging 4.7 yrs. old and 5.7 months in milk.	Before	14.8	2.71	29,844	1:5.2	21.8	.85	3.9	.70	1.0	7.6	4.8
	After	17.6	2.24	35,642	1:7.5	22.4	.92	4.1	.74	1.1	8.3	5.5

TABLE XIV.—THE TOTAL NUTRIENTS INCREASED WHEN MORE THAN 15.5 LBS.

		Per 1000 lbs. live weight.				Average per day per cow.						
		Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
		Lbs.	Lbs.	Cal.		Lbs.	Lbs.	Per ct.	Cts.	Lbs.	Lbs.	Lbs.
Average of 41 records from cows averaging 5.6 yrs. old and 4.8 months in milk.	Before	16.0	2.38	31,734	1:6.5	25.1	1.01	4.0	.60	1.0	7.4	4.7
	After	17.5	2.49	34,554	1:6.7	24.6	1.00	4.1	.56	1.1	8.1	5.3
B { Average of 28 records from cows averaging 5.6 yrs. old and 4.9 months in milk.	Before	15.7	2.19	31,179	1:6.7	25.4	1.02	4.0	.60	.9	7.2	4.5
	After	17.2	2.52	33,930	1:6.5	24.8	1.03	4.2	.59	1.0	7.9	5.2
C { Average of 13 records from cows averaging 5.7 yrs. old and 4.6 months in milk.	Before	16.7	2.78	32,930	1:6.0	24.5	.97	4.0	.58	1.0	7.8	4.9
	After	18.3	2.44	35,898	1:6.9	24.2	.94	3.9	.54	1.1	8.4	5.6

AN INCREASE OF THE TOTAL NUTRIENTS WHEN MORE THAN 15.5 LBS.

In Table XIV are the average data from 41 records when the amount of total nutrients above 15.5 lbs. was increased. There was on the average a slight increase in the amount of protein. The diminution in milk flow following the change was considerably less than usually occurs during the same time without change in the ration. There was a good average gain in weight before the change but not afterward.

With an increase of protein.—Twenty-eight of the records in each of which there was an increase of the protein show about the same average results as all the above (B, Table XIV). There was a good gain in weight before the change but some loss afterward.

With a reduction of protein.—Only 13 records show the increase of nutrients with a reduction in the amount of protein. There was but light shrinkage in the milk flow. There was a good rate of gain in weight which became much slower after the change.

A REDUCTION IN THE AMOUNT OF TOTAL NUTRIENTS WITH BUT LITTLE CHANGE IN AMOUNT OF PROTEIN.

The average data from 82 records, each of which covers a period when this change in the ration was made, are given in Table XV. The average reduction of nutrients was only about one pound. The shrinkage in milk flow was a little faster than would usually occur. The moderate rate of gain in live weight was not affected.

TABLE XV.—THE AMOUNT OF NUTRIENTS REDUCED WITH LITTLE CHANGE OF PROTEIN.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 82 records from cows averaging 4.7 yrs. old and 5.7 months in milk.	For about 18 days before change and 18 days after.	Before	15.4	2.12	30,628	1:6.9	21.3	.93
		After	14.4	2.05	28,530	1:6.7	20.6	.90

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 82 records from cows averaging 4.7 yrs. old and 5.7 months in milk.	For about 18 days before change and 18 days after.	Before	4.4	.73	1.0	7.7	5.0
		After	4.4	.74	1.0	7.3	4.9

A REDUCTION IN AMOUNT OF TOTAL NUTRIENTS WITH AN INCREASE OF PROTEIN.

The following table shows the average from 72 records when this change in the ration occurred. The falling off in milk yield was considerably greater than is usual. The rate of gain in live weight was about three-fourths pound per day before the change and less than half as fast afterward. There was an increase in cost of milk production.

TABLE XVI.—THE AMOUNT OF NUTRIENTS REDUCED WITH AN INCREASE OF PROTEIN.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs*	*Lbs.*
Average of 72 records from cows averaging 5.2 yrs. old and 5.3 months in milk.	For about 21 days before change and 18 days after.	Before	1.16	2.10	32,494	1:7.5	22.6	.90
		After	14.6	2.54	29,023	1:5.2	21.6	.88

			Fat in milk.	Approximate cost of food for one lb of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 72 records from cows averaging 5.2 yrs. old and 5.3 months in milk.	For about 21 days before change and 18 days after.	Before	4.0	.70	1.0	7.8	5.2
		After	4.1	.78	1.0	7.5	4.9

A REDUCTION IN AMOUNT OF TOTAL NUTRIENTS AND OF PROTEIN.

In Table XVII are the average data from 109 records, each of which covered periods when this reduction was made. The diminution in milk yield was about twice as much as would normally occur under ample unchanged rations. The rate of gain in live weight, which was over one-half pound per day, became very slow after the change of ration.

Table XVII.—The Amount of Nutrients Reduced and Also the Protein.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 109 records from cows averaging 4.8 yrs. old and 5.9 months in milk.	For about 17 days before change and 17 days after.	Before	16.8	2.41	33,478	1:6.6	22.2	.90
		After	14.7	2.03	29,519	1:7.2	20.5	.85

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 109 records from cows averaging 4.8 yrs. old and 5.9 months in milk.	For about 17 days before change and 17 days after.	Before	4.1	.72	1.0	8.1	5.4
		After	4.1	.73	1.0	7.5	5.0

Reducing the amount of nutrients when less than 15.5 lbs.

The average data from 127 records, each of which covers a period when the amount of total nutrients, in no case exceeding 15.5 lbs. per day per 1000 lbs. live weight, was reduced, are found in Table XVIII. The average reduction was a moderate one. The milk flow diminished somewhat more rapidly than is usual under a continuously favorable ration. The rate of gain in live weight was slow.

With but little change of protein.—The average of 67 records when there was but little change of protein with the moderate reduction of the total nutrients, shows a little less than the normal shrinkage in milk flow. Little increase in live weight occurred. (A, Table XVIII.)

With an increase of protein.—There are 27 records in which there was a decided increase of protein in the ration. The average shrinkage in milk was greater than normally occurs. There was little change in live weight. (B, Table XVIII.)

TABLE XVIII.—THE AMOUNT OF TOTAL NUTRIENTS REDUCED WHEN LESS THAN 15.5 LBS.

		Per 1000 lbs. live weight.				Average per day per cow.						
		Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
		Lbs.	Lbs.	Cal.		Lbs.	Lbs.	Per ct.	Cts.	Lbs.	Lbs.	Lbs.
Average of 127 records from cows averaging 4.5 yrs. old and 6.1 months in milk.	Before	14.8	2.15	29,393	1:6.7	19.7	.83	4.2	.73	1.1	8.0	5.2
	After	13.9	2.12	27,361	1:6.2	19.0	.81	4.3	.79	1.0	7.6	5.0
A. Average of 67 records from cows averaging 4.6 yrs. old and 5.8 months in milk.	Before	14.7	2.08	29,108	1:6.7	20.3	.90	4.4	.75	1.1	7.8	5.1
	After	13.9	2.01	27,230	1:6.6	19.9	.87	4.4	.76	1.0	7.3	4.9
B. Average of 27 records from cows averaging 5.4 yrs. old and 5.6 months in milk.	Before	15.0	1.89	30,068	1:7.9	19.9	.82	4.1	.71	1.1	8.2	5.2
	After	14.1	2.39	27,830	1:5.2	19.1	.79	4.1	.79	1.1	8.0	5.2
C. Average of 33 records from cows averaging 3.6 yrs. old and 7.3 months in milk.	Before	14.8	2.51	29,419	1:5.5	18.4	.71	3.9	.75	1.1	8.3	5.4
	After	13.7	2.12	27,243	1:6.4	17.1	.71	4.2	.83	1.1	7.9	5.2

With a reduction of protein.—The average from 33 records when there was a reduction of protein as well as of total nutrients is shown in C of the same table. These cows were somewhat younger and the stage of lactation a little later than with the others. The shrinkage in milk flow was at about twice the normal rate for this stage of lactation. There was a good gain in weight before the change but much less afterward.

REDUCING THE AMOUNT OF NUTRIENTS FROM ABOVE 15.5 LBS. TO LESS THAN THAT AMOUNT.

Table XIX shows the average from 86 records when this reduction in the amount of nutrients was made. The shrinkage in milk flow was at twice the normal rate under a favorable ration. There was an average gain in weight of about three-fourths pound per day before and none after the change of ration.

With an increase of protein.—In 45 of the above records there was an increase of protein. These show an average falling off in milk production slightly greater than normally occurs. The average gain in weight was at the rate of about one pound per day before the change of ration and less than half as much afterward. (B, Table XIX.)

With a reduction of protein.—In 41 records there was a reduction of the protein. These show a shrinkage in milk flow at about three times the normal rate. There was a moderate gain in live weight before and considerable loss after the change of ration. (C, Table XIX.)

REDUCING THE AMOUNT OF NUTRIENTS TO NOT LESS THAN 15.5 LBS.

The averages from 50 records, each of which covers a period when this reduction of nutrients was made, are found in Table XX. There was, on the average, considerable reduction of protein. The milk flow diminished somewhat more rapidly than usual. The rate of increase in live weight was a good one but somewhat slower after the change of ration.

TABLE XIX.—THE TOTAL NUTRIENTS REDUCED FROM MORE THAN 15.5 LBS. TO LESS THAN 15.5 LBS.

		Per 1000 lbs. live weight.				Average per day per cow.						
		Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
		Lbs.	Lbs.	Cal.		Lbs.	Lbs.	Per ct.	Cts.	Lbs.	Lbs.	Lbs.
Average of 86 records from cows averaging 5.3 yrs. old and 5.0 months in milk.	Before	16.9	2.21	34,134	1:7.4	24.4	.98	4.0	.68	1.0	7.6	5.1
	After	14.6	2.27	29,246	1:6.4	22.6	.93	4.1	.72	.9	7.1	4.7
B Average of 45 records from cows averaging 5.1 yrs. old and 5.1 months in milk.	Before	16.8	2.23	33,950	1:7.2	24.2	.95	3.9	.72	1.0	7.6	5.1
	After	14.9	2.64	29,739	1:5.2	23.1	.94	4.1	.78	1.0	7.3	4.8
C Average of 41 records from cows averaging 5.5 yrs. old and 5.0 months in milk.	Before	17.0	2.19	34,335	1:7.5	24.6	1.02	4.1	.65	1.0	7.5	5.0
	After	14.3	1.87	28,705	1:7.9	22.0	.91	4.1	.65	.9	6.9	4.6

Table XX.—The Total Nutrients Reduced when More than 15.5 Lbs.

		Per 1000 lbs. live weight.				Average per cow per day.						
		Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
		Lbs.	Lbs.	Cal.		Lbs.	Lbs.	Per ct.	Cts.	Lbs.	Lbs.	Lbs.
Average of 50 records from cows averaging 5.3 yrs. old and 5.7 months in milk.	Before	18.4	2.49	36,636	1:7.0	23.7	.96	4.1	.75	1.1	8.1	5.6
	After	16.4	2.16	33,134	1:7.4	22.6	.95	4.2	.70	1.1	7.7	5.2
Al Average of 15 records from cows averaging 5.5 yrs. old and 5.6 months in milk.	Before	18.6	2.29	37,415	1:7.8	25.8	1.06	4.1	.65	1.0	7.5	5.0
	After	16.9	2.22	34,335	1:7.4	23.9	1.04	4.4	.65	1.0	7.4	4.9
C Average of 35 records from cows averaging 5.2 yrs. old and 5.7 months in milk	Before	18.3	2.57	36,302	1:6.7	22.8	.92	4.0	.79	1.1	8.4	5.8
	After	16.2	2.14	32,618	1:7.4	22.0	.92	4.2	.73	1.1	7.8	5.4

With but little change of protein.—There were only 15 records when but little change of protein occurred. There was a falling off in milk yield greater than usual. The gain in live weight was at the rate of about one-half pound per day before and at about one-third pound per day after the change.

With some reduction of protein.—The average from 35 records when there was a reduction of protein shows something more than the normal shrinkage in milk flow (C, Table XX). The rate of increase in live weight, over a pound per day before the change of ration, was about half as much afterward.

REMARKS.

The proportional increase or reduction of the total nutrients in corresponding groups was not always regular but varied considerably. In general the milk flow increased most or diminished least when the highest percentage of increase was made in the amount of total nutrients, without regard to the protein content. Among the groupings of records in which the amount of nutrients was reduced, the most rapid shrinkage in milk flow occurred generally when the percentage reduction of nutrients was greatest, although this usually was associated with a reduction of the protein.

A statement of the general results accompanying changes which related to different amounts of total nutrients, is given in the summary.

THE ENERGY OF THE RATION.

As a rule, the fuel value of the ration changed in about the same proportion as the amount of total nutrients, but not always. Occasionally quite a different relation was caused by the unusual proportion of fat existing in some of the grain products fed. At the time many of these records were made cottonseed meal and some gluten feeds contained over 13 per cent. of fat, gluten meals from 12 to 21 per cent., and the ground flaxseed about 38 per cent.

The different individual records were all grouped and averaged according to variations in the fuel value above and below 30,000 Calories per day per 1000 lbs. live weight. In general, with the food used, a ration with a fuel value of 30,000 Cal. would contain 15 lbs. of total digestible organic matter.

As would be expected the comparisons of rations on the basis of energy showed the same general tendencies evidenced by the comparison of somewhat related groupings made according to the amount of total nutrients, although the effect of the protein relation was more evident.

Statement of the general results which accompanied changes in the fuel value of the ration will be found on p. 63 in the general summary.

THE PROTEIN CONTENT OF THE RATION.

In formulating rations more consideration has been always given to the protein than to other constituents both because it is so essential and because it is so seldom found in excess in the cheaper foods. The nutritive ratio is based upon the relative amount of protein. The absolute amount desirable in a ration has also been indicated in the standards. The data from the groupings of the different records made with relation to the absolute amount of protein are here presented. Those from comparisons made on the basis of nutritive ratio are later considered.

LITTLE CHANGE IN THE PROTEIN CONTENT.

The average data from 91 records which covered periods when little change in the amount of protein was made, although there was some increase of the total organic nutrients in the ration, are found in Table XXI. The falling off in milk yield was less than the normal amount. The rate of gain in live weight was slow but somewhat faster before the change than after.

TABLE XXI.—LITTLE CHANGE IN THE AMOUNT OF PROTEIN.

			For 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	Lbs.	Cal.		Lbs.	Lbs.
Average of 91 records from cows averaging 4.5 yrs. old and 4.9 months in milk.	For about 20 days before change and 19 days after.	Before	14.6	2.01	28,813	1:6.8	21.1	.91
		After	15.5	2.03	31,611	1:7.5	20.7	.91

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk. solids.
			Per ct.	Cts.	Lbs.	Lbs.	Lbs.
Average of 91 records from cows averaging 4.5 yrs. old and 4.9 months in milk.	For about 20 days before change and 19 days after.	Before	4.3	.73	.9	6.9	4.6
		After	4.4	.75	1.0	7.5	5.0

AN INCREASE OF PROTEIN.

The average of 273 records, each of which covers a period when the amount of protein in the ration was increased, is shown in Table XXII. There was, on the average, also a slight increase in fuel value. The shrinkage in milk flow was about half as great as would normally occur. The very moderate rate of gain in live weight was somewhat increased by the change.

TABLE XXII.—AN INCREASE IN AMOUNT OF PROTEIN.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 273 records from cows averaging 4.5 yrs. old and 5.2 months in milk.	For about 17 days before change and 17 days after.	Before	14.9	2.04	29,725	1:7.0	22.5	.92
		After	15.3	2.42	30,680	1:6.0	22.2	.91

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 273 records from cows averaging 4.5 yrs. old and 5.2 months in milk.	For about 17 days before change and 17 days after.	Before	4.1	.69	.9	7.2	4.7
		After	4.1	.73	1.0	7.6	4.9

A REDUCTION OF PROTEIN.

The average from 297 records which cover periods when the amount of protein in the ration was reduced give the data in the following table. There was, with this reduction, a slight lowering of the fuel value. The shrinkage in milk yield was at considerably more than the normal rate. The moderate increase in live weight was not affected by the change.

TABLE XXIII.—A REDUCTION IN AMOUNT OF PROTEIN.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 297 records from cows averaging 4.8 yrs. old and 6.1 months in milk.	For about 17 days before change and 17 days after.	Before	15.8	2.38	31,456	1:6.4	21.5	.90
		After	15.1	2.02	30,197	1:7.3	20.5	.86

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 297 records from cows averaging 4.8 yrs. old and 6.1 months in milk.	For about 17 days before change and 17 days after.	Before	4.2	.74	1.1	8 0	5.3
		After	4.2	.76	1.1	7.8	5.2

LITTLE CHANGE OF PROTEIN AND IN THE AMOUNT OF NUTRIENTS.

On the average for 49 records when there was little change in the amount of protein or of the total nutrients there followed about the normal reduction in the milk yield. The moderate rate of gain in weight was not much influenced. The following table contains the average data.

TABLE XXIV.—LITTLE CHANGE IN PROTEIN AND AMOUNT OF TOTAL NUTRIENTS.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 49 records from cows averaging 4.1 yrs. old and 4.9 months in milk.	For about 18 days before change and 18 days after.	Before	14.3	1.84	28,096	1:7.3	19.1	.86
		After	14.4	1.84	28,124	1:7.4	18.6	.82

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 49 records from cows averaging 4.1 yrs. old and 4.9 months in milk.	For about 18 days before change and 18 days after.	Before	4.5	.75	1.0	7.2	4.8
		After	4.4	.78	1.0	7.4	4.9

LITTLE CHANGE OF PROTEIN WITH AN INCREASE IN AMOUNT OF NUTRIENTS.

Thirty-five records for periods when, with little change in the amount of protein, there was an increase of total nutrients show on the average a slight increase in the milk flow—without change in the cost of production. There was a slight gain in weight before the change of ration and some loss in weight afterward.

TABLE XXV.—LITTLE CHANGE OF PROTEIN WITH AN INCREASE OF TOTAL NUTRIENTS.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 35 records from cows averaging 4.5 yrs. old and 5.0 months in milk.	For about 24 days before change and 18 days after.	Before	14.2	2,23	28,197	1:5.8	22.4	.96
		After	16.8	2,28	35,832	1:7.4	22.5	.97
			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.	
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*	
		Before	4.3	.74	.9	6.4	4.2	
		After	4.3	.74	1.1	7.8	5.1	

AN INCREASE OF PROTEIN WITH LITTLE CHANGE IN AMOUNT OF NUTRIENTS.

The average of 65 records shows, following this change in the ration, about the normal diminution in milk flow or slightly less. There was a slight average loss in live weight before and none after the change.

TABLE XXVI.—AN INCREASE OF PROTEIN WITH LITTLE CHANGE OF NUTRIENTS.

			Per 1000 Lbs. Live Weight.				Average per Day per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio	Milk yield.	Fat in milk.
			Lbs.	Lbs.	Cal.		Lbs.	Lbs.
Average of 65 records from cows averaging 4.5 yrs. old and 5.0 months in milk.	For about 15 days before change and 18 days after.	Before	14.3	1.91	28,825	1:7.2	21.9	.92
		After	14.5	2.28	29,167	1:6.0	21.4	.88

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	Cts.	Lbs.	Lbs.	Lbs.
Average of 65 records from cows averaging 4.5 yrs. old and 5.0 months in milk.	For about 15 days before change and 18 days after.	Before	4.2	.65	.9	6.8	4.4
		After	4.1	.68	1.0	7.3	4.7

AN INCREASE OF PROTEIN AND OF TOTAL NUTRIENTS.

One hundred and thirty-four records, each of which covers a period when there was an increase of total nutrients with that of the protein, show, on the average, no shrinkage in the milk yield. Without change of ration, there is usually expected, during a similar period, at this stage of lactation, a diminution of about 2.5 per cent. The very slow rate of gain in live weight was moderately increased.

TABLE XXVII.—AN INCREASE OF PROTEIN AND OF TOTAL NUTRIENTS.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
Average of 134 records from cows averaging 4.9 yrs. old and 5.0 months in milk.	For about 17 days before change and 17 days after.		*Lbs.*	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
		Before	14.5	2.03	28,734	1:6.9	22.8	.91
		After	16.2	2.42	32,479	1:6.5	22.8	.91

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
Average of 134 records from cows averaging 4.9 yrs. old and 5.0 months in milk.	For about 17 days before change and 17 days after.		*Per ct.*	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
		Before	4.0	.69	.9	7.0	4.5
		After	4.0	.73	1.0	7.8	5.1

AN INCREASE OF PROTEIN WITH SOME REDUCTION OF THE TOTAL NUTRIENTS.

The average data from 74 records when the change in ration was of this character are found in the following table. The milk yield diminished somewhat faster than it normally should. From nearly a pound per day the average rate of gain in live weight fell off to less than one-half pound per day.

TABLE XXVIII.—AN INCREASE OF PROTEIN WITH A REDUCTION OF TOTAL NUTRIENTS.

			Per 1000 lbs. live weight.				Average per day per cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 74 records from cows averaging 5.1 yrs. old and 5.3 months in milk.	For about 20 days before change and 18 days after.	Before	16.0	2.17	32,308	1:7.1	22.6	.90
		After	14.4	2.55	28,751	1:5.2	21.7	.89

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 74 records from cows averaging 5.1 yrs. old and 5.3 months in milk.	For about 20 days before change and 18 days after.	Before	4.0	.71	1.0	7.8	5.1
		After	4.1	.77	1.0	7.5	4.9

AN INCREASE OF PROTEIN WHEN LESS THAN 2 LBS. AND MORE THAN 1.6 LBS.

One hundred and twenty-seven records cover periods when such a change was made. There was also on the average a slight increase in the total nutrients. The average data are given in Table XXIX. The milk flow diminished scarcely any. There was a moderate loss in live weight before and a slow gain after the change of ration.

With little change in amount of nutrients.—When the amount of nutrients was but little changed in 53 instances there followed about the normal falling off in milk production (A, Table XXIX). Under the rations fed there was a moderate loss in live weight.

With an increase of total nutrients.—When there was an increase of the total nutrients in 65 instances there followed an appreciable increase in the milk production, and the cost of production was somewhat higher. There was some loss in live

weight before and a gain after the change of ration (B, Table XXIX).

With a reduction of nutrients.—In only 9 of the records there occurred, with this same increase of protein, a reduction in the amount of total nutrients. In these few instances there was a rapid diminution of milk flow with a much greater cost of production.

AN INCREASE OF THE PROTEIN WHEN ABOVE 2 LBS. AND LESS THAN 2.25 LBS.

There are 56 records which cover periods when this change in the ration was made. There followed a diminution of milk flow at a little less than the normal rate. The gain in live weight, fairly good before, was very little after the change. The data are found in Table XXX.

With an increase of nutrients.—After an increase of protein, with an increase in the amount of nutrients, in 28 instances there followed very much less than the usual diminution in milk flow. There was a good rate of increase in live weight before but a moderate loss after the change. See B in Table XXX.

With a reduction of nutrients.—When, with the increase of protein, there was a reduction in amount of nutrients in 28 instances, the following decrease in milk production was at a faster rate than normal. There was a good rate of gain in weight, but slower after the change.

AN INCREASE OF PROTEIN WHEN BETWEEN 2.25 LBS. AND 2.5 LBS.

The average data from 72 records which cover periods when this increase in protein content was made are found in Table XXXI. The milk flow diminished but very slightly. The live weight increased on the average faster after the change than before.

With an increase of total nutrients.—Thirty-two records cover periods when with the increase of protein there was an increase of total nutrients. The milk yield was very slightly increased. There was a loss in live weight before the change and a considerable gain afterward.

TABLE XXIX.—AN INCREASE OF PROTEIN WHEN LESS THAN 2 LBS., AND MORE THAN 1.6 LBS.

		Per 1000 lbs. live weight.				Average per day per cow.						
		Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
		Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*	*Per ct.*	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 127 records from cows averaging 5.1 yrs. old and 4.9 months in milk.	Before	14.3	1.80	28,523	1:7.6	22.4	.94	4.2	.64	.9	7.0	4.5
	After	14.9	2.19	30,125	1:6.6	22.3	.91	4.1	.70	1.0	7.5	4.8
A { Average of 53 records from cows averaging 4.9 yrs. old and 4.7 months in milk.	Before	14.3	1.81	28,728	1:7.6	22.9	.96	4.2	.61	.9	6.6	4.3
	After	14.4	2.15	29,006	1:6.3	22.3	.94	4.2	.66	1.0	6.8	4.4
B { Average of 65 records from cows averaging 5.1 yrs. old and 4.7 months in milk.	Before	14.2	1.80	28,227	1:7.7	22.7	.91	4.0	.66	.9	7.2	4.6
	After	15.6	2.22	31,564	1:6.9	23.1	.92	4.0	.72	1.0	7.8	5.1

TABLE XXX.—AN INCREASE OF PROTEIN WHEN ABOVE 2 LBS., AND LESS THAN 2.25 LBS.

		Per 1000 lbs. live weight.				Average per day per cow.						
		Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
		Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*	*Per ct.*	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 56 records from cows averaging 4.1 yrs. old and 5.2 months in milk.	Before	15.6	2.08	31,444	1:7.4	22.1	.86	3.9	.72	1.0	7.6	4.8
	After	15.6	2.43	31,014	1:6.1	21.6	.84	3.9	.77	1.0	7.6	5.1
B Average of 28 records from cows averaging 4.3 yrs. old and 5.2 months in milk.	Before	14.8	2.11	29,690	1:7.7	22.7	.91	4.0	.66	.9	7.0	4.3
	After	16.4	2.48	32,650	1:6.5	22.6	.93	4.1	.68	1.0	7.6	4.9
C Average of 28 records from cows averaging 4.0 yrs. old and 5.2 months in milk.	Before	16.4	2.04	33,198	1:8.0	21.5	.82	3.8	.80	1.1	8.2	5.4
	After	14.9	2.39	29,379	1:5.7	20.6	.82	3.8	.85	1.0	7.6	5.2

TABLE XXXI.—AN INCREASE OF PROTEIN WHEN BETWEEN 2.25 AND 2.5 LBS.

		Per 1000 lbs. live weight.				Average per day per cow.						
		Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
		Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*	*Per ct.*	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 72 records from cows averaging 4.8 yrs. old and 5.6 months in milk.	Before	15.1	2.32	30,248	1:6.1	22.2	.89	4.0	.75	1.0	7.3	4.8
	After	15.5	2.70	31,121	1:5.3	22.1	.88	4.0	.77	1.0	7.8	5.1
B Average of 32 records from cows averaging 4.4 yrs. old and 5.6 months in milk.	Before	14.9	2.30	29,303	1:5.9	22.2	.89	4.0	.81	.9	7.1	4.8
	After	17.0	2.65	33,702	1:5.9	22.3	.91	4.1	.81	1.0	8.0	5.4
C Average of 28 records from cows averaging 5.5 yrs. old and 4.9 months in milk.	Before	15.7	2.31	31,752	1:6.4	24.3	.97	4.0	.66	.9	7.2	4.7
	After	14.2	2.69	28,706	1:5.0	24.0	.98	4.1	.71	.9	6.9	4.3

With some reduction of nutrients.—The average of 28 records which cover periods when there was a reduction of nutrients with the same increase of protein as above is shown in C of Table XXXI. There occurred a diminution in milk yield at about half the normal rate. The gain in live weight was much slower after the change than before.

AN INCREASE IN THE AMOUNT OF PROTEIN ABOVE 2.5 LBS.

Only 18 records cover periods when this change in the ration occurred. With half of them there was an increase of total nutrients and with half a reduction. There was a more than usually rapid falling off in milk for both groups. On the average there was a slight increase in amount of nutrients. The average shrinkage in milk was twice as much as it would normally be. The gain in live weight was much slower after the change of ration. Little change in the cost of production occurred.

TABLE XXXII.—AN INCREASE OF PROTEIN WHEN ABOVE 2.5 LBS.

			PER 1000 LBS LIVE WEIGHT.				AVERAGE PER DAY PER COW.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
Average of 18 records from cows averaging 5.3 yrs. old and 5.0 months in milk.	For about 23 days before change and 24 days after.		*Lbs.*	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
		Before	15.4	2.52	30,759	1:5.8	25.5	1.05
		After	16.0	2.89	31,792	1:5.0	23.3	.96
			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.	
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*	
		Before	4.1	.60	.8	6.6	4 3	
		After	4.1	.60	.9	7.4	4.9	

A REDUCTION OF PROTEIN WITH LITTLE CHANGE IN AMOUNT OF NUTRIENTS.

One hundred records which cover periods when there was a reduction of the protein with little change in amount of nutrients give the average found in Table XXXIII. Following this change there was just about the normal decrease in milk yield. The moderate rate of increase in live weight was slightly increased.

TABLE XXXIII.—A REDUCTION OF PROTEIN WITH LITTLE CHANGE OF NUTRIENTS.

			Per 1000 lbs. live weight.				Average per day per cow.	
			Total digestible organic matter.	Digestible protein	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	Lbs	Cal.		Lbs.	Lbs
Average of 100 records from cows averaging 4.7 yrs. old and 7.1 months in milk.	For about 15 days before change and 18 days after.	Before	15.2	2.23	30,155	1:6.7	19.	.81
		After	15.1	1.84	30,016	1:7.9	18.	.81

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	Cts.	Lbs.	Lbs.	Lbs.
Average of 100 records from cows averaging 4.7 yrs. old and 7.1 months in milk.	For about 15 days before change and 18 days after.	Before	4.2	.80	1.1	8.4	5.5
		After	4.3	.80	1.1	8.2	5.6

A REDUCTION OF PROTEIN WITH SOME INCREASE IN AMOUNT OF NUTRIENTS.

The average for 58 records when this change in the ration was made is shown in the following table. The accompanying reduction in milk yield was slight, much less than would normally occur for a similar period. The live weight increased much faster after the change.

TABLE XXXIV.—A REDUCTION OF PROTEIN WITH SOME INCREASE OF TOTAL NUTRIENTS.

			Per 1000 lbs. live weight.				Average per day per cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 58 records from cows averaging 5.0 yrs. old and 5.2 months in milk.	For about 18 days before change and 15 days after.	Before	14.6	2.56	29,211	1:5.5	22.6	.93
		After	16.1	2.16	32,191	1:7.2	22.4	.90

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 58 records from cows averaging 5.0 yrs. old and 5.2 months in milk.	For about 18 days before change and 15 days after.	Before	4.1	.67	1.0	7.4	4.7
		After	4.0	.70	1.1	8.0	5.2

A REDUCTION OF PROTEIN AND OF THE TOTAL NUTRIENTS.

The average data from 139 records when both the protein and total nutrients were reduced follow in Table XXXV. The milk yield fell off at a rate about twice as fast as the normal one. There was a moderate increase in live weight before the change of ration and none afterward.

TABLE XXXV.—A REDUCTION OF PROTEIN AND OF TOTAL NUTRIENTS.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs*	*Lbs.*
Average of 139 records from cows averaging 4.8 yrs. old and 5.8 months in milk.	For about 18 days before change and 17 days after.	Before	16.7	2.41	33,328	1:6.6	22.5	.92
		After	14.8	2.09	29,495	1:6.9	21.0	.90

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 139 records from cows averaging 4.8 yrs. old and 5.8 months in milk.	For about 18 days before change and 17 days after.	Before	4.1	.72	1.0	7.9	5.4
		After	4.3	.74	1.0	7.3	4.9

A REDUCTION OF THE PROTEIN WHEN MORE THAN 2.5 LBS.

One hundred twenty-three records when there was this reduction of protein give the average data found in Table XXXVI. The average yield of milk diminished at about half the normal rate. The rate of increase in live weight, at about one-half pound per day, was not affected.

With little change in amount of nutrients.—When there was little change in the amount of nutrients in 31 instances the average result shown in A of Table XXXVI was obtained—which was practically the same as the total average above given.

With an increase of total nutrients.—In 47 instances, when an increase of total nutrients occurred, there followed no reduction in the milk yield, but a slight average increase. The rate of gain in weight from about one-half pound per day became about one pound per day. (B, Table XXXVI.)

With a reduction of total nutrients.—When there was a moderate reduction in the amount of total nutrients there followed,

8

TABLE XXXVI.—A REDUCTION OF THE PROTEIN WHEN ABOVE 2.5 LBS.

		Per 1000 lbs. live weight. Total digestible organic matter.	Per 1000 lbs. live weight. Digestible protein	Per 1000 lbs. live weight. Fuel value.	Per 1000 lbs. live weight. Nutritive ratio.	Average per day per cow. Milk yield.	Average per day per cow. Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
		Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Per ct.*	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 123 records from cows averaging 4.5 yrs. old and 6.2 months in milk.	Before	15.7	2.73	31,153	1:5.4	20.8	.83	4.0	.74	1.1	8.3	5.5
	After	15.8	2.27	31,509	1:6.6	20.5	.82	4.0	.74	1.1	8.1	5.4
A. Average of 31 records from cows averaging 4.8 yrs. old and 6.9 months in milk.	Before	15.5	2.65	30,832	1:5.7	21.3	.83	3.9	.61	1.0	8.2	5.2
	After	15.8	2.00	31,635	1:7.3	21.0	.82	3.9	.64	1.0	7.7	5.3
B. Average of 47 records from cows averaging 4.7 yrs. old and 5.6 months in milk	Before	15.0	2.74	29,912	1:5.2	21.4	.86	4.0	.71	1.0	7.8	4.9
	After	16.7	2.28	33,247	1:7.0	21.5	.86	4.0	.72	1.1	8.4	5.5
C. Average of 45 records from cows averaging 4.0 yrs. old and 6.4 months in milk.	Before	16.5	2.79	32,672	1:5.3	19.7	.77	3.9	.85	1.1	8.8	6.4
	After	14.9	2.44	29,615	1:5.8	19.2	.79	4.1	.83	1.1	8.0	5.3

on the average for 45 instances, about the normal shrinkage in milk yield. The rate of increase in live weight was noticeably reduced.

A reduction of the protein when above 2.25 and less than 2.5 lbs.

The only records available which show this reduction of protein show a corresponding reduction of the total nutrients; 54 records give, following this change in the ration, an average reduction in the milk flow about three times as great as should occur at the same stage of lactation. There was some loss in live weight but much less before the change of ration than afterward.

Table XXXVII.—A Reduction of the Protein When Between 2.25 and 2.5 Lbs.

			Per 1000 Lbs. Live Weight.				Average Per Day Per Cow.	
			Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.
			Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*
Average of 54 records from cows averaging 4.9 yrs. old and 5.4 months in milk.	For about 18 days before change and 19 days after.	Before	17.3	2.38	34,455	1:6.7	24.2	.99
		After	14.9	2.05	29,961	1:7.1	22.1	.93

			Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
			Per ct.	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 54 records from cows averaging 4.9 yrs. old and 5.4 months in milk.	For about 18 days before change and 19 days after.	Before	4.1	.63	1.0	7.5	5.0
		After	4.2	.72	.9	6.7	4.6

A reduction of the protein when above 2 lbs., under 2.25 lbs.

The 65 records which cover periods when this change in the ration was made show an average decrease in milk flow considerably greater than it should normally be. There was a very good increase in live weight.

TABLE XXXVIII.—A REDUCTION OF THE PROTEIN WHEN ABOVE 2 LBS., AND LESS THAN 2.25 LBS.

		Per 1000 lbs. live weight.				Average per day per cow.						
		Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
		Lbs.	Lbs.	Cal.		Lbs.	Lbs.	Per ct.	Cts.	Lbs.	Lbs.	Lbs.
Average of 65 records from cows averaging 5.1 yrs. old and 7.0 months in milk.	Before	15.4	2.11	30,641	1:6.9	19.0	.85	4.5	.84	1.1	8.4	5.6
	After	14.5	1.84	28,483	1:7.5	18.1	.83	4.6	.85	1.2	8.3	5.5
A. Average of 43 records from cows averaging 4.9 yrs. old and 7.0 months in milk.	Before	14.8	2.11	29,197	1:6.6	18.1	.80	4.4	.89	1.2	8.4	5.6
	After	14.6	1.84	28,594	1:7.6	17.5	.80	4.6	.90	1.2	8.5	5.7
C. Average of 22 records from cows averaging 5.6 yrs. old and 6.9 months in milk.	Before	16.5	2.12	33,464	1:7.5	20.8	.96	4.6	.72	1.1	8.3	5.5
	After	14.2	1.85	28,266	1:7.3	19.2	.92	4.8	.75	1.1	7.9	5.2

Table XXXIX.—A Reduction of the Protein when Less than 2 Lbs., More than 1.6 Lbs.

		Per 1000 lbs. live weight.				Average per day per cow.						
		Total digestible organic matter.	Digestible protein.	Fuel value.	Nutritive ratio.	Milk yield.	Fat in milk.	Fat in milk.	Approximate cost of food for one lb. of milk.	Dry matter in food for one lb. of milk.	Dry matter in food for one lb. of milk solids.	Digestible dry matter in food for each lb. of milk solids.
		Lbs.	*Lbs.*	*Cal.*		*Lbs.*	*Lbs.*	*Per ct.*	*Cts.*	*Lbs.*	*Lbs.*	*Lbs.*
Average of 55 records from cows averaging 5.1 yrs. old and 5.4 months in milk.	Before	14.9	1.89	30,150	1:7.7	23.3	.98	4.2	.73	1.0	7.3	4.8
	After	14.7	1.66	29,527	1:8.7	22.0	.92	4.2	.72	1.0	7.4	4.9
A Average of 26 records from cows averaging 4.4 yrs. old and 7.3 months in milk.	Before	15.3	1.93	30,933	1:8.0	19.4	.83	4.3	.88	1.1	8.6	5.6
	After	15.1	1.67	30,445	1:9.1	18.5	.78	4.2	.85	1.2	8.4	5.7
C Average of 18 records from cows averaging 5.5 yrs. old and 4.1 months in milk.	Before	15.6	1.88	31,418	1:8.0	26.4	1.13	4.3	.66	.9	6.6	4.4
	After	14.6	1.65	29,325	1:8.5	24.3	1.07	4.4	.60	.9	6.5	4.4

With but little change in total nutrients.—The amount of total nutrients was but little changed in 43 instances. The milk flow diminished at a little more than the usual rate. The average increase in live weight was considerably greater after the change.

With some reduction of nutrients.—The average for 22 instances, when considerable reduction in amount of nutrients occurred, shows a falling off in milk twice as great as is usual. The gain in live weight was much less after the change of ration.

A REDUCTION OF THE PROTEIN WHEN LESS THAN 2 LBS., MORE THAN 1.6 LBS.

The average data from 55 records when such a reduction occurred are found in Table XXXIX. The average shrinkage in milk was at about twice the normal rate. There was but little change in live weight.

With but little change in amount of nutrients.—After this change in the ration, when the amount of nutrients was but little affected, there was, on the average in 26 instances, a reduction of milk yield considerably greater than should normally occur. The data are in A of Table XXXIX.

With some increase in amount of nutrients.—Only 11 records cover periods when with such a reduction of protein the nutrients were increased. In these cases the amount of total nutrients was small, and there was a continual loss of live weight. The milk flow diminished but little faster than usual. There was some increase in the cost of production.

With some reduction in amount of nutrients.—There are only 18 of the records which show this change of ration. In these the shrinkage in milk flow was at about three times the normal rate.

REMARKS.

In general changes in the amount of protein within the ordinary limits produced less effect than changes in the amount of total nutrients. The average results which followed the differ-

ent modifications of the ration as related to the protein content are briefly summarized on p. 64 at the beginning of this bulletin.

THE NUTRITIVE RATIO.

The effects of changes in the nutritive ratio, as a rule, of course were directly in line with those evidenced by the groupings of the rations on the basis of protein content as related to differing amounts of total organic nutrients. The unusual amount of fat in a few foods caused considerable difference in some of these relations of ratio to the actual amount of protein in the ration.

It is unnecessary to give all the data from the averages made to show the general effect of changes in nutritive ratio. In considering the records on this basis they were grouped with relation to the ratio of 1:6, although the majority of the rations had a wider ratio, principally because the standards in general call for a ration with this nutritive ratio or one narrower.

Moderate changes in the nutritive ratio within the ordinary limits had considerable less effect on the milk flow than did changes in the amount of total digestible organic matter. The general results accompanying different modifications of the ration which affected the nutritive ratio are stated on p. 65 of the general summary.

REPORT

OF THE

Department of Botany.

F. C. Stewart, *Botanist.*

H. J. Eustace, *Student Assistant.*

Table of Contents.

AN EPIDEMIC OF CURRANT ANTHRACNOSE.*

F. C. STEWART AND H. J. EUSTACE.

SUMMARY.

During the past season the currant crop in the Hudson Valley has been seriously injured by anthracnose, a fungous disease causing the appearance of numerous small, dark brown spots on the leaves, which turn yellow and fall prematurely. Currant canes were quite generally defoliated early in the season and the exposure of the ripening fruit to the sun brought about sun-scald, resulting in a loss of nearly one-half the crop in some plantations.

The disease attacks the leaves, petioles, fruit, fruit stems and canes. In New York State it is present among currants almost every season, but there is no record of its destructive occurrence since 1889. Although it attacks also gooseberries and black currants it has not injured them in the same locality where red currants have been seriously damaged by it. It is readily distinguished from the ordinary leaf spot by the size of the spots, which are much smaller.

The weather conditions last spring seem to have been particularly favorable to it; but judging from the past history of the disease it is not likely to become a constant pest. Fruit growers need not be alarmed. Probably, it will become epidemic only occasionally.

Although there are scarcely any experimental data at hand, it is likely that anthracnose may be prevented by spraying with Bordeaux mixture; and since currant worms make necessary at least one application of Bordeaux, and leaf spot (a

* A reprint of Bulletin No. 199.

disease known to be preventable by spraying) is always more or less prevalent, and it seems likely that the destructive disease known as cane blight may be checked, it is recommended that currants in the Hudson Valley be sprayed regularly every season.

INTRODUCTION.

The region between Highland and Newburgh in the Hudson River Valley is the principal fruit-growing section of Eastern New York. Grapes, peaches, raspberries and currants are grown extensively. Currants are grown more extensively here than in any other part of the State. They constitute one of the leading fruit crops in this famous fruit-growing section.

While visiting this locality June 13 and 14, 1901, we observed that the currant foliage was quite generally affected with a form of leaf blight or anthracnose caused by the fungus *Glœosporium ribis*. The lower leaves were yellow and thickly covered with very small brown spots. Almost all the currant plantations were more or less affected and the presence of the disease could be detected at a considerable distance by the yellow color of the foliage. In some cases the leaves were already dropping quite freely. Fruit growers were alarmed. They were not accustomed to see the currant foliage behave in this way.

Since there seemed liable to be an epidemic of this somewhat unusual disease we planned to watch its progress. During the remainder of the season we made frequent visits to the locality and kept close watch on the disease, particularly in a badly affected plantation on the farm of Mr. J. A. Hepworth near Milton. This plantation consisted of about five acres in a peach orchard on high, well-drained, slaty soil.

SYMPTOMS.

The disease works from below, upward. The lower leaves become thickly covered with small dark-brown spots, turn yellow and fall. The disease appears in June and continues active throughout the season or until the bushes have been completely defoliated. In the present case it must have appeared rather

suddenly and become epidemic about June 8. When we made our first observations, June 13, it was already so abundant that fruit growers were cognizant of it. Ten days earlier we had spent two days visiting fruit plantations in this same locality and at that time we neither saw nor heard of any trouble with currants except cane blight which is always destructive there.[1] Although we were seeking the diseases of raspberries rather than those of currants, it is likely that the currant anthracnose would have come to our attention had it been at all abundant at that time. In a letter dated June 10, Mr. A. B. Clarke, of Milton, states that it was very abundant in his plantation at that date.

During June the affected plantations were readily recognized, even at a considerable distance, by the yellow color of the foliage; but in July this was much less noticeable. By July 10 the few leaves still remaining on the bushes were scarcely at all yellow although thickly covered with anthracnose spots. By June 26 the fruit was beginning to ripen and thereafter the affected plantations were to be recognized by their conspicuous red color. The falling of the leaves left the load of ripening fruit exposed to view.

In addition to the leaves, the fungus attacked the leaf stalks or petioles, causing conspicuous black, slightly sunken spots. It also attacked the fruit stems, the berries and the new canes. The spots on the fruit stems were black and resembled those on the petioles. They were from one-fourth to one-half inch in length and extended half way or more around the stem. On the berries the spots were black and circular and bore some resemblance to fly specks. While the berries were green the spots on them were fairly numerous and readily seen; but as the berries ripened the spots became less conspicuous. This may have been due to the fact that the small berries toward the tip of the cluster were the ones most severely attacked and as a result many of them dropped before ripening. The affected berries did not rot; and the presence of the spots on the fruit stems

[1] See Bul. 167 of this Station, p. 292.

seemed to affect the berries but slightly. Very rarely did the berries wither from this cause. Peck's[2] statement that the fungus does not attack the berries is certainly an error.

Thinking it possible that the fungus attacks also the wood, we made a close examination of the canes in the badly affected Hepworth plantation and were immediately rewarded by the discovery of yellowish pustules which upon microscopic examination proved to be the acervuli or spore conceptacles of *Glœosporium ribis.* This was on July 10. Most of the acervuli seemed immature, but some of them contained spores identical with those found on the leaves, thus leaving no doubt that *Glœosporium ribis* occurs on currant canes. At our next visit, July 23, it was found that the acervuli were mostly mature and contained an abundance of typical *G. ribis* spores. A quality of the affected canes was collected and preserved. They will probably be distributed in Seymour and Earle's *Economic Fungi.* So far as observed, the acervuli occur only on wood of the present season's growth. The color of the acervuli is pale yellow or light brown and differs but little from that of the cane. Consequently, they are inconspicuous. However, when they are numerous, one acquainted with them may locate them with the unaided eye. The fungus seems to do very little harm to the cane, producing but a trifling discoloration of the bark and none at all of the wood.

We believe this to be the first account of the discovery of *Glœosporium ribis* on currant canes. Considering the inconspicuousness of the acervuli, it is not strange that they have been overlooked. It is also possible that under ordinary circumstances the fungus does not attack the canes. Whenever a plant disease becomes epidemic it is likely to behave somewhat differently from its usual manner. However, be this as it may, the discovery is an important one because it shows where the fungus probably passes the winter and that the canes are to be considered a source of infection in the spring.

---

[2]Peck, C. H. Rep. N. Y. State Mus. Nat. Hist., 43:52.

HOW DISTINGUISHED FROM OTHER CURRANT LEAF DISEASES.

Among fruit growers the currant disease under consideration is usually known as leaf blight or sometimes as leaf spot. Since there are at least two other common currant leaf diseases which go by the same name much confusion would be avoided if fruit growers would follow the custom of mycologists and call this disease anthracnose. Mycologists apply the name anthracnose to diseases caused by species of fungi belonging to *Glœosporium*, *Colletotrichum* and a few other closely related genera.

The currant disease which is properly called leaf spot is the one caused by the fungus *Septoria ribis* Desm. This produces on the leaves dead, brown (or gray) spots which are usually circular in outline and have a dimeter of about one-eighth inch (See Plate I, Fig. 3). As a rule, leaf spot is readily distinguished from anthracnose by the size of the spots, anthracnose spots being much smaller—often no larger than a pin head. However, the spots formed by *Septoria ribis* on both red and black currants, may sometimes be angular and quite small, although always larger than those of *Glœosporium ribis*. A notable example of this came under our observation at Milton where a large plantation of black currants, *Ribes nigrum*, was quite severely attacked by leaf spot as early as July 10. Since, at this date, *Septoria ribis* had shown itself only in traces on red currants in this locality, and the character of the spots was so much out of the ordinary, we were much surprised to find that the trouble was due to *Septoria ribis*. The spots were quite angular and scarcely more than one-third their usual size. The variety of currant is one said to have originated near Milton where it is known as the Mackey.

The Septoria leaf spot is very common in New York and is usually the chief cause of the dropping of currant leaves in this State; but during the past season it was almost wholly absent from the locality where anthracnose was epidemic until about

EXPLANATION OF PLATE I.

FIG. 1. *A leaf of red currant affected with anthracnose,* Glœosporium ribis. *Natural size.*

FIG. 2. *Spores of* Glœosporium ribis. *Magnification 825 diameters.*

FIG. 3. *A leaf of red currant affected with leaf spot,* Septoria ribis. *Natural size.*

FIG. 4. *A leaf of red currant showing the work of the four-lined leaf-bug,* Pœcilocapsus lineatus. *Natural size.*

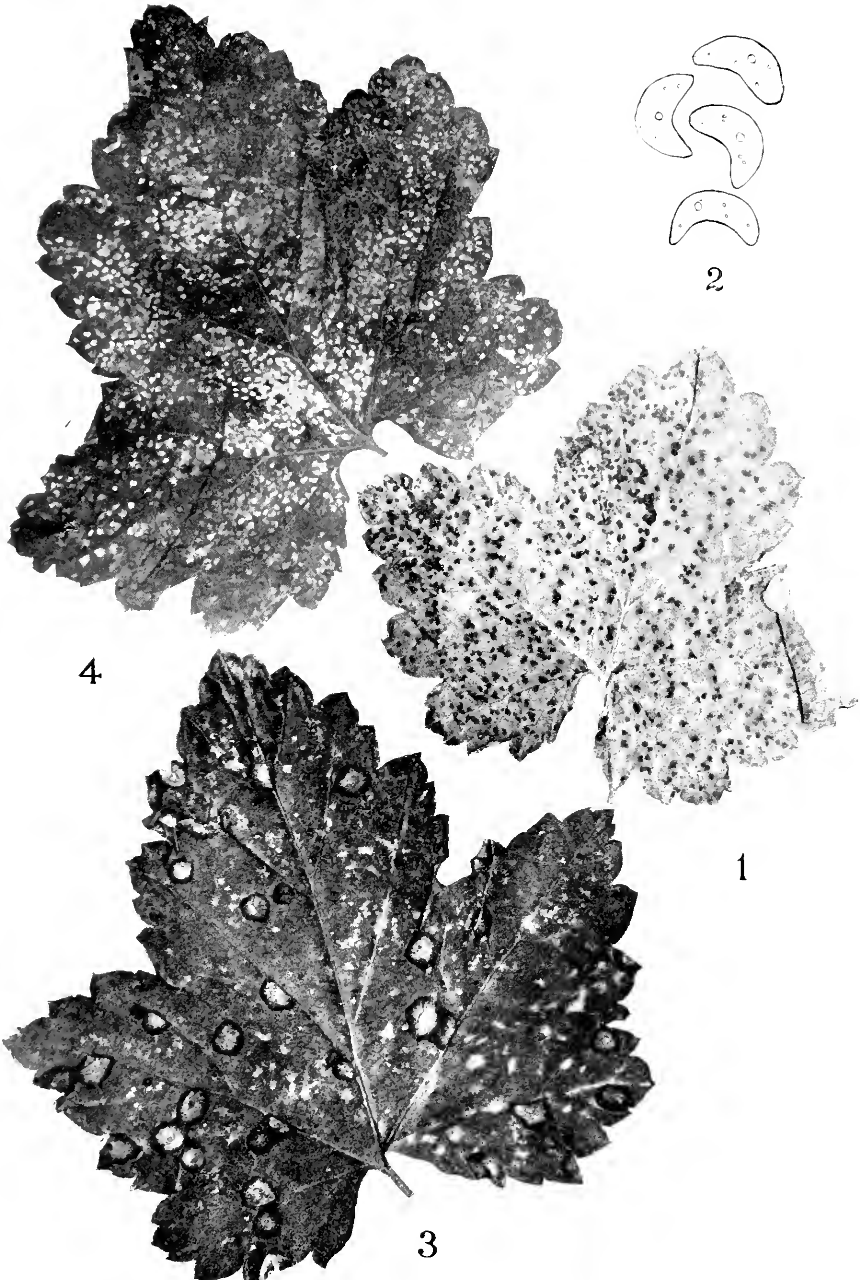


Plate I.—Common Leaf Diseases of the Currant.

July 23, when it appeared in abundance and destroyed the few leaves left by anthracnose.

Another form of so-called leaf spot which occurs on currant leaves in the Hudson Valley, sometimes in considerable abundance is that caused by the four-lined leaf-bug, *Pœcilocapsus lineatus*.[3] The spots caused by this insect are angular and translucent or else black with a water-logged appearance. (See Plate I, Fig. 4). They are wholly different in appearance from anthracnose spots and, moreover, they occur on leaves at the tips of the canes; whereas, anthracnose appears first on the lower leaves and may attack leaves on any part of the plant.

A third leaf disease of currants is one which may be called leaf blight. It is caused by the fungus *Cercospora angulata* Wint. According to Pammel[4] this fungus is common on currants in Iowa.

In New York State it seems to be rare. In 1897 we received specimens of it from Highland, and in 1900 specimens were sent us from Long Island. During the past season we have sought for it in the Hudson Valley, but have not found even a trace of it. The spots formed by it are considerably larger than anthracnose spots.

Occasionally we have met with a form of leaf spot caused by a species of *Phyllosticta*. The spots are larger even than those of *Septoria ribis* so there need be no danger of confusing them with anthracnose spots.

THE FUNGUS.

Glœosporium ribis (Lib.) Mont. & Desm.

The fungus which is the cause of currant anthracnose was named *Glœosporium ribis* by Montagne and Desmazieres[5] in 1867. For some time previous it had been known as *Leptothyrium ribis*, which name is, therefore, a synonym. *Cryptosporium ribis* Fckl. is also a synonym.

As already stated, it attacks the leaves, petioles, fruit stems,

[3] See Bul. 167 of this Station, p. 291; also Cornell Agr. Exp. Sta. Bul. 58.

[4] Pammel, L. H. Iowa Exp. Sta. Bul. 13.67.

[5] Montagne & Desmazieres. Kickx' Flore crypt. Flandres 2:95.

fruit and canes. The spores are formed in pustules, technically known as acervuli, which originate underneath the epidermis of the leaf, chiefly on the upper surface. The epidermis becomes blackened and elevated so as to form a small pimple. At maturity this pimple is ruptured at the summit and the spores escape in a gelatinous mass which appears as a whitish or flesh colored speck at the center of the spot. The spores, which are one-celled and uncolored, are somewhat variable as to size and shape. Usually they are strongly curved and somewhat larger at one end. (See Plate I, Fig. 2.) As we have found them, the spores measure 12 to 24 μ in length by 5 to 9 μ in width, the most common size being 19 by 7 μ.

In our experience there has never been any difficulty to find the spores in abundance on the affected leaves. They are also fairly abundant on the new canes and on the petioles. On the canes they are much more easily found while the canes are fresh. Upon drying, the contrast of color distinguishing the acervuli largely disappears. From dried specimens of the canes the spores are most easily obtained by scraping the bark after a brief immersion in water. On the fruit stems and berries the spores are found less frequently.

So far as known, *Glœosporium ribis* has but the one spore form above described. However, it is quite possible that there exists, also, an ascigerous form in which the fungus passes the winter. Fuckel[6] has suggested such a relationship with *Sphœria circinata* Fckl. [=*Gnomoniella circinata* (Fckl.) Sacc.]

By means of artificial cultures Miss Stoneman[7] has shown that two other species of *Glœosporium*, *G. cingulatum* Atk. and *G. viperatum* E. & E., have in their life cycle ascigerous forms referable to a pyrenomycetous genus for which she proposes the name *Gnomoniopsis*.

Excellent figures of *Glœosporium ribis* are found in Briosi & Cavara's *Funghi parassiti delle piante coltivate od utili*, Fasc. IX, Nr. 222.

---

[6] Fuckel. L. Symbolæ Mycologieæ, p. 111.

[7] Stoneman, Bertha. A Comparative Study of the Development of some Anthracnoses. *Botanical Gazette*, 26:101–106.

Other species of *Glœosporium* attacking members of the genus *Ribes*, the genus to which the cultivated currants and gooseberries belong, are *G. curvatum* Oud. on leaves of *R. nigrum*, the black currant; *G. tubercularioides* Sacc. on leaves of *R. aureum*, the Missouri currant; and *G. ribicolum* E. & E. on fruit of the English gooseberry.

AMOUNT OF DAMAGE DONE.

Although the fungus *Glœosporium ribis* is widely distributed over Europe, Asia, Australia and North America, and has long been known to mycologists, it seems to have attracted very little attention as a fungus of economic importance. While it is frequently mentioned in works on fungi, it is not often spoken of as doing any serious damage to currants.

The first mention of its occurrence in this country seems to have been that made by Berkeley,[8] in 1873, who reported it on leaves of black currant collected in Connecticut. In 1884 Peck[9] found it on the leaves of the fetid currant, *Ribes prostratum*, in the Adirondacks. According to Dudley[10] and also Peck[11] there was a serious outbreak of the disease in New York State in the season of 1889. Prof. Dudley, at that time Cryptogamic Botanist of the Cornell Experiment Station, made the disease the subject of a two-page article which was published as a part of Bulletin 15 of that Station and also in the Annual Report of the same Station for 1889. Although so brief that Prof. Dudley himself called it a note, the article is, even to the present time, the most comprehensive published account of currant anthracnose as it occurs in America. He reports[12] the disease abundant on white currants at Ithaca and destructive to red currants in the vicinity of Rochester. Peck[13] says: "A currant-leaf fungus, *Glœosporium ribis*, has also

---

[8] Berkeley, M. J. *Grevillea*, 2:83.

[9] Peck, C. H. Rep. N. Y. State Mus. Nat. Hist., 38:98.

[10] Dudley, W. R. Cornell Agr. Exp. Sta. Bul. 15:196–198; same in Second Ann. Rep. Cornell Agr. Exp. Sta., 1889, pp. 196–198.

[11] Peck, C. H. Rep. N. Y. State Mus. Nat. Hist., 43:52.

[12] Dudley. Loc. cit.

[13] Peck. Loc. cit.

been excessively virulent. In some localities currant leaves have been so severely attacked by it that their vigor was destroyed and they fell to the ground long before the usual time. In my own garden the currant bushes were as destitute of foliage in August as they usually are in November."

Since 1889 it has been mentioned by Pammel[14] as occurring on red currants in Iowa and Halsted[15] has reported its occurrence on cultivated gooseberries in New Jersey; but we find nothing in the literature to indicate that ithasbeen at all destructive during the past eleven years. However, from our own observations we are inclined to believe that in New York, particularly in the Hudson Valley, it occurs to some extent nearly every season and that, in some instances, it has been destructive. June 12, 1897, Mr. H. R. Leeder of New Paltz reported to the station that his currants were dropping their leaves badly. The specimen leaves accompanying his letter showed an abundance of *Glœosporium ribis* which was probably the cause of the leaves dropping. It is noteworthy that this outbreak,like the one of the present season, occurred before the middle of June. On July 7 of the same year Mr. F. A. Sirrine observed that in the vicinity of Highland currants were dropping their leaves badly. Specimens of the fallen leaves were examined by one of the writers of this article and found to be infested with *Cercospora angulata* and *Glœosporium ribis*. June 28, 1900, we observed a plantation of red currants on Long Island which was severely attacked by *Glœosporium ribis*. *Septoria ribis* was also present in small amount. In this plantation the *Glœosporium* had attacked the fruit stems to so great an extent as to attract the attention of the foreman in charge. Nevertheless, we saw no evidence of damage from this cause. None of the berries were dropping or shriveling. Dr. B. M. Duggar informs us that *Glœosporium ribis* was abundant on cur-

---

[14] Pammel, L. H. *Journal of Mycology*, 7:101. In a letter dated November 5, 1901, Prof. Pammel writes us that he has not observed the disease in Iowa since 1891.

[15] Halsted, B. D. N. J. Agr. Coll. Exp. Sta. Report for 1895, p. 331.

rants in the Hudson valley in the autumn of 1900. In a plantation at Rochester we found a few currant bushes quite severely attacked by *G. ribis*, August 30, 1900; but this was the only case of the disease observed in western New York last year. The season was an excessively dry one.

During the past season currant anthracnose became epidemic in the Hudson valley about June 8. By June 13 many leaves were falling and it was already evident that the crop would be considerably injured. In some plantations one-half the foliage was gone by June 26 and by July 10 the bushes were completely defoliated except for small tufts of leaves at the tips of some of the canes. The fruit commenced to ripen about June 26 and by July 10 the harvest was in progress. About July 1 there was a week of excessive heat with a clear sky. As a result, currants throughout the Hudson Valley suffered severely from sunscald. Most of the leaves having fallen, the fruit was left exposed to the direct rays of the sun. However, it is likely that the injury was not all due to exposure to the sun. Some of it was probably due to the inability of the defoliated canes to supply the berries with water notwithstanding the fact that the soil was filled with water owing to frequent showers. The loss from sunscald and shriveling of the berries was enormous. Mr. Hepworth has 18 acres of currants from which he sold, in 1900, 50,000 quarts of fruit. In 1901 the same plantation yielded only 26,000 quarts. This loss of nearly one-half the crop Mr. Hepworth attributes to the effect of anthracnose and the accompanying sunscald. In the five-acre plantation mentioned in the introduction to this bulletin the loss was estimated to be about two-thirds of the crop. The fruit set as well in 1901 as in 1900 and there was no other disease besides anthracnose except cane blight, which was no more destructive in 1901 than in 1900. Therefore, had it not been for the anthracnose the crop of 1901 would probably have been as large as that of 1900. Moreover, the loss on the present season's fruit crop is not all. The dropping of the leaves so early in the season must seriously interfere with the proper ripening of the

wood and the formation of fruit buds for next year. How great will be the damage from this cause can not be determined until next season. As already stated, some plantations were almost completely defoliated by July 10. By July 22 many plantations were completely defoliated and many more had lost from one-half to two-thirds of their foliage. As a rough estimate we would say that in the region between Highland and Newburgh probably two-thirds of all currant leaves (excepting black currants) had fallen by July 22. About this time *Septoria ribis* also appeared and assisted in completing the destruction. At what time the defoliation was completed we are unable to say, since we did not visit the region between July 22 and September 2. On the latter date very few green currant leaves were to be found; and yet, normally, currants hold their leaves until heavy frost. On the station grounds, at Geneva, sprayed currants of many different varieties were in nearly full foliage as late as October 15.

The disease was more destructive in old plantations than among young plants. Plants in the nursery row were attacked latest of all and consequently suffered least. It was a common observation among fruit growers that the disease was more severe on high, dry soil than in lower situations where the soil was heavier and naturally moister. Our own observations confirmed this. The disease was also somewhat less severe on plants which were partially shaded. It is a common practice in the Hudson Valley to plant currants between the rows in peach orchards. Hence, it comes about that many bushes are in partial shade. The shaded plants were not attacked so early as were those fully exposed to the sun.

Concerning the amount of damage done by currant anthracnose elsewhere than in the Hudson Valley, we have little information. At Geneva, some plantations lost a large part of their foliage because of anthracnose, and it was present in greater or less amount in almost all plantations; but the damage done by it does not appear to have been great. Prof. Craig informs us that the disease was common at Ithaca.

HOST PLANTS.

While *Glœosporium ribis* may attack several different species of *Ribes*, it has a decided preference for *R. rubrum* to which belong the red and white varieties of cultivated currants. It has been frequently reported on *R. nigrum*, the black currant, but according to our observations it is not at all destructive to black currants, to say the least. While watching the progress of the disease in the Hudson Valley we examined several plantations of black currants, but in no case found any damage done to them by anthracnose. In one case a row of black currants stood between two rows of red ones. The red currants were all severely attacked by anthracnose, but the foliage of the black currants was perfect and apparently free from the disease.

The cultivated gooseberry, *Ribes grossulariæ*, is also said to be subject to anthracnose. In the region where anthracnose was epidemic on currants there are several commercial plantations of gooseberries none of which were affected by the disease to any extent.

It also appears that among the red currants some varieties are somewhat more susceptible than others. Our observations on this point are not as full as they should be and so we are unable to give a list of resistant varieties; but it is probable that this difference in susceptibility is sufficiently great to be turned to practical account in case anthracnose should become an important factor in currant culture.

On July 23, when the disease was in full sway, we made some observations at Middle Hope where four varieties of red currant, Fay Prolific, Victoria, Prince Albert and Pres. Wilder, were growing in the same plantation under practically the same conditions. On Fay Prolific, anthracnose had caused about two-thirds of the foliage to drop and Victoria had lost about one-third of its foliage; while Prince Albert and Pres. Wilder were perfect in foliage and practically free from the disease. Gooseberries growing nearby were also unaffected.

THE OUTLOOK FOR THE FUTURE.

The question has been asked, Will anthracnose be destructive next season? Also, Is it likely to appear regularly every season hereafter and become a menace to the currant industry? It is our opinion that currant growers need not be alarmed. Anthracnose is by no means a new disease of currants. It has existed in the currant plantations of New York for at least twelve years and probably longer. In 1889 it was destructive; but since that time there is no published record of any damage done by it in this State. Judging from the past history of the disease it seems unlikely that it will become troublesome except in an occasional season when all conditions are favorable to it.[16] However, we are not unmindful of the fact that diseases which spring suddenly into prominence as the currant anthracnose has done during the past season sometimes continue to be very destructive. Striking examples of this are afforded by the cucumber downy mildew, *Plasmopara cubensis*, and the asparagus rust, *Puccinia asparagi*. The former first appeared in this country in 1889 and has since become so destructive in the Eastern United States that the growing of late cucumbers must have been abandoned had it not been discovered that the disease can be controlled by spraying.[17] The first epidemic of asparagus rust occurred in 1896 in New Jersey, Long Island and Southern New England.[18] Prior to 1896 it was practically unknown in America; but each season since 1896 it has been destructive and seems to be established as a permanent scourge of asparagus.

---

[16] Exactly what weather conditions are most favorable to the disease is not known. The two epidemics of recent years in this State have both occurred in wet seasons (1889 and 1901) and naturally we infer that wet weather is favorable to the disease. However, Dr. Weiss states (Weiss, J. E. Die Blattfallkrankheit der Johannisbeersträucher. *Praktische Blätter für Pflanzenschutz*, 3:3), that in southern Bavaria the disease was epidemic in the dry seasons of 1898 and 1899, but scarcely any damage was done in the wet season of 1897.

[17] For the history of *Plasmopara cubensis* see Bul. 119 of this Station, p. 164.

[18] Halsted, B. D. N. J. Exp. Sta. Bul. 129.

Concerning the outlook for currants in 1902, it is safe to predict that the crop in the Hudson Valley will be somewhat shortened, owing to the premature falling of the leaves last summer; but the virulence of anthracnose will probably depend very largely upon the nature of the weather next spring The prevalence of the disease in 1901 is certainly favorable to another epidemic in 1902, provided the weather conditions are favorable. The new wood and fallen leaves are everywhere covered with multitudes of the spores ready to start infection again next spring if they have a chance. In the Hudson Valley, the spring of 1901 was a very wet one as was also the spring of 1889 when the other epidemic occurred; so it appears that the disease is favored by wet weather.

TREATMENT.

If it becomes necessary to fight currant anthracnose resort must be had to spraying, which seems to be the only promising line of treatment, except, perhaps, the planting of resistant varieties. Spraying with the copper compounds, particularly Bordeaux mixture, is effective against many fungous diseases of foliage and there is little doubt that currant anthracnose may be controlled in this way. However, there is but little experimental data bearing on this point. Prof. Pammel[19] at the Iowa Experiment Station, has conducted more experiments on the spraying of currants than any one else in this country and shown that *Septoria ribis* and *Cercospora angulata* may be controlled by spraying with Bordeaux mixture; but *Glœosporium ribis* was not a factor in any of his experiments. Dr. Halsted[20] made the following experiment: " In a row of eight gooseberry bushes, two were selected for treatment. Beginning April 25, three applications of Bordeaux were made previous to May 22. The bushes were again sprayed August 13. The foliage was somewhat injured by an anthracnose (*Glœosporium ribis* Lib.), but there was

---

[19] Pammel, L. H. Iowa Agr. Exp. Sta. Bul. 13:45–46; Bul. 17:419–421; Bul. 20:716–718; Bul. 24:987–988; Bul. 30:289–291.

[20] Halsted, B. D. N. J. Agr. Coll. Exp. Sta. Rep. for 1895, p. 331.

no practical difference between the sprayed and unsprayed plants." As far as they go, the results of this experiment are unfavorable to the control of currant anthracnose by spraying.

Currant growers in the Hudson Valley fully realize the importance of protecting their plants against the ravages of currant worms[21] which strip the bushes of their leaves in a surprisingly short time. Of late years they have abandoned the use of hellebore, the standard remedy for currant worms, and substituted for it Bordeaux mixture containing Paris green, green arsenoid or some other arsenical poison. Promptly upon the first appearance of the worms the bushes are given a thorough spraying with the poisoned Bordeaux mixture. If the work is well done, and rains not too frequent, a single application suffices for the season. Whereas, if hellebore is used it is usually necessary to make two or more applications, because there are generally two and sometimes three broods of worms during the season and the

[21] Two distinct species of currant worms occur in the Hudson Valley, which not only differ in appearance but also in habits. The one generally known as the currant span-worm, called gooseberry span-worm in some sections (*Diastictis ribearia*), is single brooded; while the imported currant-worm or currant saw-fly (*Nematus ventricosus*), has two broods each year. The larva of the first is a caterpillar. They appear early, sometimes before the currant leaves are even fairly expanded. They grow rapidly and feed voraciously. By the last of May or first of June they are full grown and stop feeding. At this time they are about one inch long, of a bright yellow color, marked with white lines on the sides together with numerous black spots and dots. They can also be distinguished from the imported currant-worm by their habit of looping the body when they travel. These worms leave the bushes about the first of June and go into the ground where they change to the chrysalis form. Early in July they issue as adult moths or millers and can be seen flying over the fields during July and part of August. In color the adult moth is pale yellow with dusky spots or bands on the wings. Seen at a distance it could easily be mistaken for the butterfly of the cabbage-worm flying over the currant fields. The eggs are deposited on the branches of the currants and do not hatch until the following spring.

The imported currant-worm is the slug-like caterpillar of a saw-fly. The flies appear about the time the span-worm hatches from the egg. They pair first, then lay their eggs upon the underside of the currant leaves, usually along the larger veins. The eggs hatch a week or ten days after being deposited. Owing to the time required for laying and hatching the eggs, the worms do not appear until one or two weeks after the span-worm has commenced feeding. The larvæ of the saw-fly reach

hellebore applied for the first brood is washed off by rain before the appearance of the second brood. Bordeaux mixture, on the contrary, is not readily removed by rain and enough of it still remains on the leaves to kill the second brood of worms. Besides requiring but a single application, the Bordeaux mixture has an additional advantage in that it protects the foliage, to a considerable extent, against leaf spot. The superiority of Bordeaux mixture[22] is so evident that the use of hellebore has been almost entirely abandoned, except in cases where the application has been postponed until the fruit is so large that there is danger of spotting it if Bordeaux is used. The application of the poisoned Bordeaux is made upon the first appearance of worms; but last spring the worms appeared somewhat later than usual and so the Bordeaux was applied later. In fact, many persons accustomed to spray for worms did not do so the past season because there were so few worms that it seemed unnecessary.

---

maturity in June, at which time they are about three-quarters of an inch long. They go to the ground and spin cocoons around themselves in which they change to chrysalides. During July they change again to adult flies; as a result a second brood of worms occurs after the crop of fruit is gathered. This worm can be distinguished from the span-worm by its color, which is usually green covered with black dots, with the extremities sometimes tinged with yellow; also by the fact that it does not loop the body when it travels, but does frequently curl itself up sidewise when feeding.

In most sections of the country the last described species is usually the most common currant pest. When hellebore is recommended, this is the worm that is supposed to be doing the damage.

The currant growers of the Hudson Valley have two distinct species of worms to combat and these worms appear at three distinct periods. This would require not only frequent applications of hellebore but also large quantities of it. Such treatment is expensive. The use of hellebore has also proven worthless as a remedy for the span-worm, as shown by the fact that in 1897 the fields in the vicinity of Highland, even where hellebore was applied frequently, were completely stripped by this pest. These conditions have done much to induce growers to use some arsenical compound in Bordeaux mixture.—F. A. SIRRINE.

[22] It appears that poisoned Bordeaux mixture as a remedy for currant worms came into use in the Hudson Valley about 1898. It was recommended by Mr. F. A. Sirrine in a short article published in the *Eastern New York Horticulturist* for October, 1897. Mr. J. A. Hepworth of Marlborough and Messrs. W. D. Barns & Son of Middle Hope were among the first to use it.

Some persons thought they saw evidence that the single application of Bordeaux for worms had lessened the amount of damage from anthracnose. In the plantation of Mr. A. B. Clarke at Milton, we observed that in one portion anthracnose was considerably more severe than in an adjacent portion. Upon inquiry as to the cause we were informed that one portion had been sprayed once with Bordeaux mixture while the other had not. In this case there appeared to be a marked benefit from spraying; but in general the Bordeaux applied for worms did not have much effect on the anthracnose. Probably the application was made too late.

In the absence of experimental data we can only make suggestions as to treatment. Bordeaux mixture will probably control the disease, but the spraying must be commenced early. In view of the fact that the anthracnose fungus inhabits the canes, the first application should be made on the bare canes before the leaves appear.[23] Special attention should be given to the new wood because there is where the spores are most abundant. In fact no spores have yet been found on the old wood. However, the old wood should also be sprayed, because it is possible that some spores do occur on it, and also because of the possible effect on cane blight. How the fungus of cane blight gets into the canes is not known, but there is good reason for believing that thorough spraying of the canes will have a tendency to prevent

---

[23] For the first treatment a strong solution of copperas (iron sulphate) may be used instead of the Bordeaux. Make a saturated solution (that is, add copperas to water until no more will dissolve) and apply while the buds are swelling but *before they break*. By some, this treatment is thought to be beneficial for grape anthracnose (See N. Y. Agr. Exp. Sta. Bul. 86:79; and Bul. 170:410), particularly when about one per cent. of sulphuric acid is added to the copperas solution. But if the sulphuric acid is added the mixture can not be applied with a spraying machine, because it is so very corrosive. In that case it must be applied with a swab or whisk broom. The fungus of grape anthracnose is closely related to that of currant anthracnose and there is some reason for believing that any treatment which is successful for the one would be successful for the other. Nevertheless we have recommended Bordeaux mixture for the first treatment for the following reasons: (1) Bordeaux is likely to be equally effective; (2) The treatment is less complicated; (3) There is no danger of injury to the plants or to the sprayer.

its attacks. The second spraying should be made while the leaves are unfolding, and thereafter the treatment should be repeated at intervals of ten to fourteen days until there is danger of permanently spotting the fruit. Upon the appearance of worms add Paris green or green arsenoid to the mixture. In wet seasons one or two applications should be made after the fruit is gathered.

Spraying in the early part of the season should be done with especial thoroughness and regularity in order, if possible, to keep the diseases completely under control until the time when the spraying must be discontinued on account of spotting the fruit.

To restate the matter briefly: Spray thoroughly with Bordeaux mixture, commencing before the leaves appear. Make the second treatment as the leaves are unfolding and thereafter at intervals of ten to fourteen days until the fruit is two-thirds grown. In wet seasons make one or two applications after the fruit is gathered. When worms appear add Paris green or green arsenoid to the Bordeaux.

It seems to us probable that currant growers in the Hudson Valley will find spraying, as suggested above, a profitable practice. Anthracnose may not be epidemic except occasionally, but it probably does some damage nearly every season. Leaf spot is nearly always plentiful in the latter part of the sesaon, and sometimes causes the leaves to fall before the fruit is ripe. Cane blight is always destructive, and one application must be made for the worms anyway. We believe that loss from all these troubles may be materially lessened by spraying. While the currant bears premature defoliation remarkably well, preservation of the foliage must result in increased vigor of the plants and, consequently, larger yields of fruit.

NOTES FROM THE BOTANICAL DEPARTMENT.*

F. C. STEWART AND H. J. EUSTACE.

SUMMARY.

I. In a nursery cellar at Rochester 25,000 pear trees were seriously injured by thawing too suddenly. The sand covering the roots of the trees had become frozen, and in order to facilitate the removal of the trees a fire was built in the cellar. A few days later it was found that the upper parts of all the trees had turned black. Although the trees were practically uninjured for planting, it was impossible to dispose of them at wholesale, and they were almost a total loss to their owner.

II. The shot-hole fungus so destructive to the foliage of cherries and plums has been discovered attacking the fruit-pedicels of cherries. This discovery is of considerable scientific interest, but it has little or no practical bearing on the control of the disease.

III. The fungus of antirrhinum anthracnose which was supposed to be confined exclusively to the antirrhinum has recently been found on a common weed called yellow toad-flax. Since this weed may communicate the disease to the antirrhinum, the treatment of the disease on the latter is a more complicated matter than has been supposed.

IV. It has been observed that imperfectly fertilized peaches may attain considerable size and remain hanging on the trees until September. In such cases this trouble may be mistaken for the "little peach" disease by persons unfamiliar with the latter. However, in the "little peach" disease the pit is of normal size and provided with a well-developed kernel; while in

*A reprint of Bulletin No. 200.

cases of imperfect fertilization the pit is abnormally small and has no kernel, or at least only a partially developed one. This difference will enable anyone to distinguish readily between the two troubles.

V. At Milton, N. Y., the tile drain to a vinegar cellar was clogged by a luxuriant growth of the fungus *Leptomitus lacteus.* The obstruction was easily and effectually removed by placing a small quantity of copper sulphate crystals in the upper end of the drain.

VI. Drain pipes to refrigerators frequently become clogged with a slimy, gray growth of fungus which has its origin in the ice, but is not an accumulation of matter from the ice. It may be easily controlled by occasionally washing out the drain pipe and ice chamber with boiling water.

I. TROUBLE WITH PEARS IN A NURSERY CELLLAR.

In March of the present year the Station received a letter from a Rochester nurseryman requesting that an expert be sent to his place to inquire into the cause of a serious trouble among the pear trees in his nursery cellar. One of the writers of this article was sent to investigate. It was found that 25,000 three-year old standard pear trees had been tied into bundles of ten to fifteen trees each and placed in the nursery cellar in an upright position. The bundles of trees were set in rows and the roots covered with sand, after the usual custom in such cases. The bark on the trunks and branches of the trees was of normal color and apparently all right up to a height of about three and one-half feet, but above this point the bark was black, and many of the branches were evidently dead. This condition prevailed throughout the cellar in a strikingly uniform manner. All parts of the trees below three and one-half feet were healthy and all parts above that point blackened. This blackening of the branches was suggestive of the bacterial fire blight and the owner was fearful that it might be an outbreak of that disease.

Observing that a fire had been built in the cellar, suspicion at once pointed in that direction, and after an inquiry into all the

details of the case it became plain that the trouble was due to the trees having been thawed out too suddenly.

The trees were of many different varieties, and yet all were equally affected. Had it been due to fire blight or any other parasitic diseases, some varieties would have been injured more than others and some individuals more than others. On the disease hypothesis it is also impossible to account for the uniformity of height at which the trees were affected. When the trees were placed in the cellar in the autumn they were all right, and an examination of some trees in the same blocks which had remained over winter in the field showed that none of them had blackened branches. Also, some of the same lot of trees which had been stored in another cellar were free from the trouble.

For many years it has been the practice of the owner of the trees to keep the temperature of the cellar as nearly as possible at 32° F., and whenever the temperature tends to fall below 32° an open wood fire is built on the floor of the cellar. In the present case, however, no fire was built during the winter. Hence, early in the winter the sand about the roots of the trees froze to a depth of perhaps three inches and remained frozen until February. On February 25, 1200 of the trees were dug out of the frozen sand and packed for shipment. No complaint was received concerning the condition of these trees, so it may be assumed that they were not affected with the branch blackening either before or after removal from the cellar. At this time all trees in the cellar appeared to be all right.

So much difficulty was experienced in removing the trees from the frozen sand that it was decided to build a little fire in the cellar and thaw the sand. The fire was built February 27 in one corner of the cellar where the 1200 trees had been removed two days earlier. A few days later the trees were observed to be in the unhealthy condition above described. Our own observations were made March 15. The fire had not been suspected as being the cause of the trouble because it had long been the custom to build fires in cold weather. The man who built the fire admitted that it had been made a little larger than usual in order

to thaw the sand as quickly as possible. However, it is unlikely that the fire was excessively hot, because, if it had been, some bundles of trees standing close to it would have been badly scorched, whereas only a few of the most exposed trees were slightly scorched on the exposed side of the trunk. Otherwise these trees were scarcely more injured than trees at the opposite end of the cellar.

The heated air rose to the ceiling (which was about seven and one-half feet above the floor and very tight), spread out over its entire surface and then accumulated in a layer of uniform thickness. This layer of warm air was warmest at the ceiling and became cooler the nearer it approached the floor. The tips of the branches, being nearer the ceiling, were enveloped in air warmer than that surrounding the basal portions of the branches and the trunks. They were also smaller. Consequently the upper parts of the trees thawed out more quickly than the trunks. Now, it is a well-known fact that frozen plants which may be thawed without injury, if the thawing is done slowly, may be ruined if thawed suddenly. It appears that the pear trees were thawed too suddenly, and that the line marking the boundary between the injured and uninjured portions marks the height above which thawing progressed too rapidly for safety. That the temperature of the air was a more important factor than the size of the branches is shown by the fact that one bundle of Bartletts, in which the trees were so short that they did not project above the danger line, was wholly uninjured.

The majority of the trees were of such a height that their branches were blackened for a distance of six to eighteen inches. Only in a few instances did the injury extend quite to the trunk. With a few exceptions, the blackened branches might have been cut away without removing more of the tops than is customary in transplanting; and since it is unlikely that the branches were injured below the point of discoloration, the trees were practically unhurt for planters' use. Nevertheless, the trees, which were worth about $2000, were almost a total loss to their owner. Twelve thousand of them were sold for $100, to a man who cut

them back and planted them, losing less than two per cent, although they were not set until May 1. The owner states that had he been doing a retail business he could undoubtedly have disposed of a large proportion of the stock at a fair price, but it was impossible to sell it at wholesale.

II. SHOT-HOLE FUNGUS ON CHERRY FRUIT PEDICELS.

In New York State the shot-hole fungus, *Cylindrosporium padi* Karst., does more or less damage every season. It is destructive to both plums and cherries in the nursery and in the orchard. During the past season it was unusually destructive. Among cherries, the variety English Morello is especially susceptible to the disease. Trees of this variety were dropping their leaves quite freely as early as June 26 and in some cases the trees were nearly defoliated by August 1.

On June 26, while examining some seriously affected English Morello trees at Milton, it was observed that many of the fruit-pedicels bore brown spots of considerable size. Upon microscopic examination it was found that the spots were caused by the shot-hole fungus, *Cylindrosporium padi.*

On July 11 the same thing was observed at Highland. In this case there was a long row of English Morello trees, all heavily loaded with fruit. So many leaves had fallen that the trees looked bare. The fruit-pedicels were so generally attacked by the fungus that it was somewhat difficult to find one which was entirely free from the brown spots. The spots were from one-eighth to one-fourth inch in length and extended one-third to one-half the distance around the pedicel. In many cases they completely encircled the pedicel. Often the spots coalesced, and then a large portion, or even all, of the pedicel was brown. Even with the unaided eye one could detect a white speck or, more often, a white rift, at the center of each spot. With the aid of a hand lens it could be plainly seen that the white specks were gelatinous spore masses. The affected pedicels almost invariably showed an abundance of the spores. The same was

true at Milton two weeks earlier and also at Geneva, on July 13. There was no difficulty whatever in finding the spores.

The presence of the spots on the pedicels caused the fruit to ripen unevenly. Many of the fruits were dwarfed and some of those most severely attacked withered. However, these injuries cannot, with justice, be attributed wholly to the spots on the pedicels. The premature falling of the leaves, also, had something to do with it.

We believe this to be the first record of the occurrence of *Cylindrosporium padi* on the fruit-pedicels of cherry. We do not say positively that such is the case, because we have not made an exhaustive examination of the literature; but it is at least safe to say that the fact is not generally known, because it is not mentioned in any of the many accounts examined by us.

In connection with the appearance of *Cylindrosporium* on the fruit-pedicels we have observed a spotting of the green fruits which gave cherry growers in the vicinity of Geneva considerable concern last spring. It was first brought to our attention by the Station Horticulturist, Mr. Beach, about June 15. The fruits, which were at that time about the size of peas, showed numerous small, brown, slightly sunken spots. As the fruits grew many of them became somewhat misshapen, seemingly as a consequence of the presence of the spots. The spots enlarged but little and there was no tendency to rot.

In the vicinity of Geneva this trouble was exceedingly common on English Morello and Montmorency Ordinaire, and fruit growers were fearful that the crop would be injured; but as the cherries began to swell and color in ripening the spots seemed to disappear, so there was little or no loss from it.

The cause of this spotting is unknown to us. Because of its constant association with *Cylindrosporium padi* on English Morello at Geneva, Milton and Highland it was at first suspected that it might be due to that fungus. However, no evidence of the presence of any fungus could be found on the spots. Moreover, Montmorency Ordinaire, which was little affected by *Cylindrosporium* on the foliage, had nearly if not quite as much

of the fruit spot as had English Morello. These two facts, particularly the latter, are opposed to the theory that the spots were due to *Cylindrosporium padi.*

III. ANTHRACNOSE OF YELLOW TOAD-FLAX.

On June 26, 1901, while passing through a peach orchard infested with the common weed variously known as Yellow Toad-flax, Butter-and-Eggs, and Ramsted, it was observed that some of the plants were dying. Upon making an examination of the affected plants it was found that the trouble was due to an anthracnose which was attacking the plants near the surface of the ground. For a distance of two to four inches above the surface of the ground the stems were pitted with elliptical sunken spots almost identically like those produced by *Colletotrichum antirrhini* on stems of the cultivated snapdragon, *Antirrhinum majus.*[1]

Since the Yellow Toad-flax, *Linaria vulgaris* Mill., belongs to the same family, Scrophulariaceæ, as the cultivated snapdragon, it is not strange that it should be attacked by the snapdragon anthracnose. However, no case of the kind had ever been observed, although we had sought carefully for it. In fact, the disease was known only on the snapdragon, hence the following statement in our Bulletin[2] 179: "So far as known at present, this anthracnose attacks no other plant besides the Antirrhinum. Therefore, the florist whose grounds are free from the disease will have no trouble so long as he propagates only from his own stock or from seed. In such a case the source of danger is in diseased cuttings and plants from other establishments."

Upon the discovery of an anthracnose on the Yellow Toad-flax we immediately became interested to know if it was really the same as the snapdragon anthracnose. It is important to know this, because Yellow Toad-flax is a common weed of wide

---

[1] For an account of anthracnose on snapdragon, see Bul. 179 of this Station.

[2] Stewart, F. C. An anthracnose and a Stem Rot of the Cultivated Snapdragon. N. Y. Agr. Exp. Sta. Bul. 179:109.

distribution, and if it serves as a host plant for the fungus of snapdragon anthracnose the problem of controlling the latter disease is a more complicated matter than has been supposed.

Accordingly we made a thorough examination of the disease and the fungus causing it. The majority of the spots were black with the acervuli of a *Colletotrichum*. Setæ and spores were abundant. The leaves on the diseased portion of the stem were nearly all dead and brown. Close examination revealed the presence of anthracnose spots on the dead leaves and there were also a few spots on the living leaves, but the leaf spots were inconspicuous and not abundant. In all morphological characters the fungus agrees fully with *Colletotrichum antirrhini* and there is little doubt but it is that fungus. However, positive proof depends on cross inoculations with pure cultures. These have not been made.

It was found that many small plants had been killed outright by the disease, but that there were also many others which, although their stems were covered with the spots, were, nevertheless, flowering and apparently thriving. While the disease evidently does some damage to the wood, it seems unlikely that it can be turned to any practical account as an aid in its eradication.

The original place of discovery was near Milton on a steep hillside in a rather dry situation where the plants were partially shaded by peach trees. Later it was found in similar situations on two other farms at Milton and also at Middle Hope.

IV. IMPERFECT FERTILIZATION AND THE LITTLE PEACH DISEASE.

During the past few years peach growers in Michigan and in Western New York have been much concerned over the appearance of a new and destructive disease known as the "little peach" disease. It appears to have been first described by Taft[3] in March, 1898. In October of the same year a more extensive

[3]Taft, L. R. Mich. Agr. Exp. Sta. Bul. 155:303–304.

account was published by Smith.[4] The latter article has been widely quoted in the horticultural journals. Thus far no remedy for the disease has been found, and even the cause of it is still unknown. However, it is announced that Mr. M. B. Waite, an expert connected with the United States Department of Agriculture, has the subject under investigation and it is confidently believed that we shall know considerably more about the disease in the near future.

Since so much has been said about the disease and it is known to occur in various parts of New York State, particularly in Niagara County, our fruit growers are constantly on the lookout for it.

During the past season a fruit grower of Penn Yan suspected that the "little peach" disease had made its appearance in his orchard. Upon investigation it proved to be simply a case of imperfect fertilization. Of course imperfect fertilization is common among peaches, but this case had some unusual features making it worthy of record. Moreover, there are undoubtedly many fruit growers, like the one at Penn Yan, who have read of the "little peach" disease, but having never seen it are unable to distinguish it with certainty from the effects of imperfect fertilization. Hence, it seems desirable to give a detailed account of the Penn Yan case.

The orchard was composed of 150 ten-year-old trees of the variety Globe. Occasional trees of several other varieties were intermingled. The owner stated that enough fruit had set to make a full crop. In fact, he expected to be obliged to thin it; but the great majority of the fruits failed to develop, although most of them remained hanging on the trees until ripening time. He estimated that the yield of marketable fruit was between one-eighth and one-sixth of a full crop, the money loss being about $500. Our observations were made September 25. At that time most of the marketable fruit had been gathered, but the majority of the small imperfect fruits were still on the

[4] Smith, Erwin F. Notes on the Michigan Disease Known as "Little Peach." *The Fennville* (Mich.) *Herald.* Oct. 15, 1898.

trees. On the same tree and even on the same branch one could find fruits of all sizes from one-half inch in length up to normal fruits having a circumference of about eight inches. (Plates II-V). The majority of them were smaller than a normal peach pit. For the most part the little fruits were normal in color and free from rot. However, some of the smallest were somewhat shriveled. Nearly all of them below the size of a walnut could be cut, without much difficulty, directly through the pit, which was abnormally small and rather soft. Fruits of this size were usually without any kernel in the pit. Those which were one-half to two-thirds normal size often had pits with kernels which had partially developed and then decayed. Frequently the cavity was filled with gum. The little fruits were often mis-shapen. Many were double and some triple.

It is not unusual to find unfertilized peach fruits in the spring, little woolly things which fall early in the season in what is called the "June drop." The *unusual* feature of the present case is the fact that the unfertilized fruits hung on the trees until ripening time and some of them made considerable growth. Had they fallen at the usual time they would not have attracted attention, but it would simply have been said that the fruit did not set well.

Why this particular orchard should behave in this way is not clear. So far as can be learned the orchard has received no unusual treatment which would account for such a condition. That it was partly due to some peculiarity of the variety is shown by the fact that trees of other varieties, viz., Old Mixon, Stevens Rareripe, Hill Chili, Smock, Stump and Elberta, which were intermingled with the Globe trees, all bore a full crop and with the exception of Elberta none of them showed any sign of the trouble. Elberta showed a little of it. Still it cannot be wholly a question of varieties, because last year the same trees bore a full crop of fine fruit; and the owner has never before noticed any of the trouble.

Most of the trees were in a fair condition of general health. For the most part the leaves were dark green and there had been a fairly good growth of new wood. Last year there was a full

crop of fruit, but it was thinned so that the trees were not injured by overbearing. The soil is a sandy loam, well drained, and the air drainage is fairly good. The soil has been cultivated every year and no other crop has been grown between the rows except when the trees were small. Last spring the orchard was not plowed until about June 1, and then the soil baked so hard that there was much difficulty in pulverizing it again. No manure was applied in the fall of 1900 and none in the spring of 1901. In the early life of the trees the owner thought they grew too fast and so manure was withheld from them somewhat.

The intermingling of the other varieties seemed to have no effect upon the Globe. Globe trees standing adjacent to trees of other varieties having a full crop of fruit were quite as much affected as trees standing at a considerable distance from other varieties.

In the "little peach" disease the pit is of normal size and contains a well developed kernel, whereas in this case the pit is abnormally small and contains no kernel or at most only an abortive one. Herein lies the most striking difference between "little peach" and the effects of imperfect fertilization. Plates III and IV show natural-size photographs of thirteen peaches, all from one tree. Plate IV also shows natural-size photographs of the pits from these thirteen fruits. Number one was a normal fruit, while the others were undersized as a consequence of imperfect fertilization. By comparing the photographs of the fruits with the photographs of their pits it will be seen that there is an intimate relation between the size of a fruit and the size of its pit. Also that the majority of the pits were far below the normal size. The latter is also shown in a striking manner by the weights of the pits as given in the accompanying table:

TABLE SHOWING WEIGHTS OF PEACH PITS.

Pit No. 1 weighed....	6.96 grams.	Pit No. 7 weighed....	.80 grams.
Pit No. 2 weighed....	6.24 grams.	Pit No. 8 weighed....	.50 grams.
Pit No. 3 weighed....	5.05 grams.	Pit No. 9 weighed....	.40 grams.
Pit No. 4 weighed....	2.41 grams.	Pit No. 10 weighed....	.20 grams.
Pit No. 5 weighed....	1.15 grams.	Pit No. 11 weighed....	.20 grams
Pit No. 6 weighed....	1.24 grams.	Pit No. 12 weighed....	.20 grams.
		Pit No. 13 weighed....	.05 grams.

Plate II.—Full-sized Peach on Twig with Imperfectly Fertilized Small Peaches.

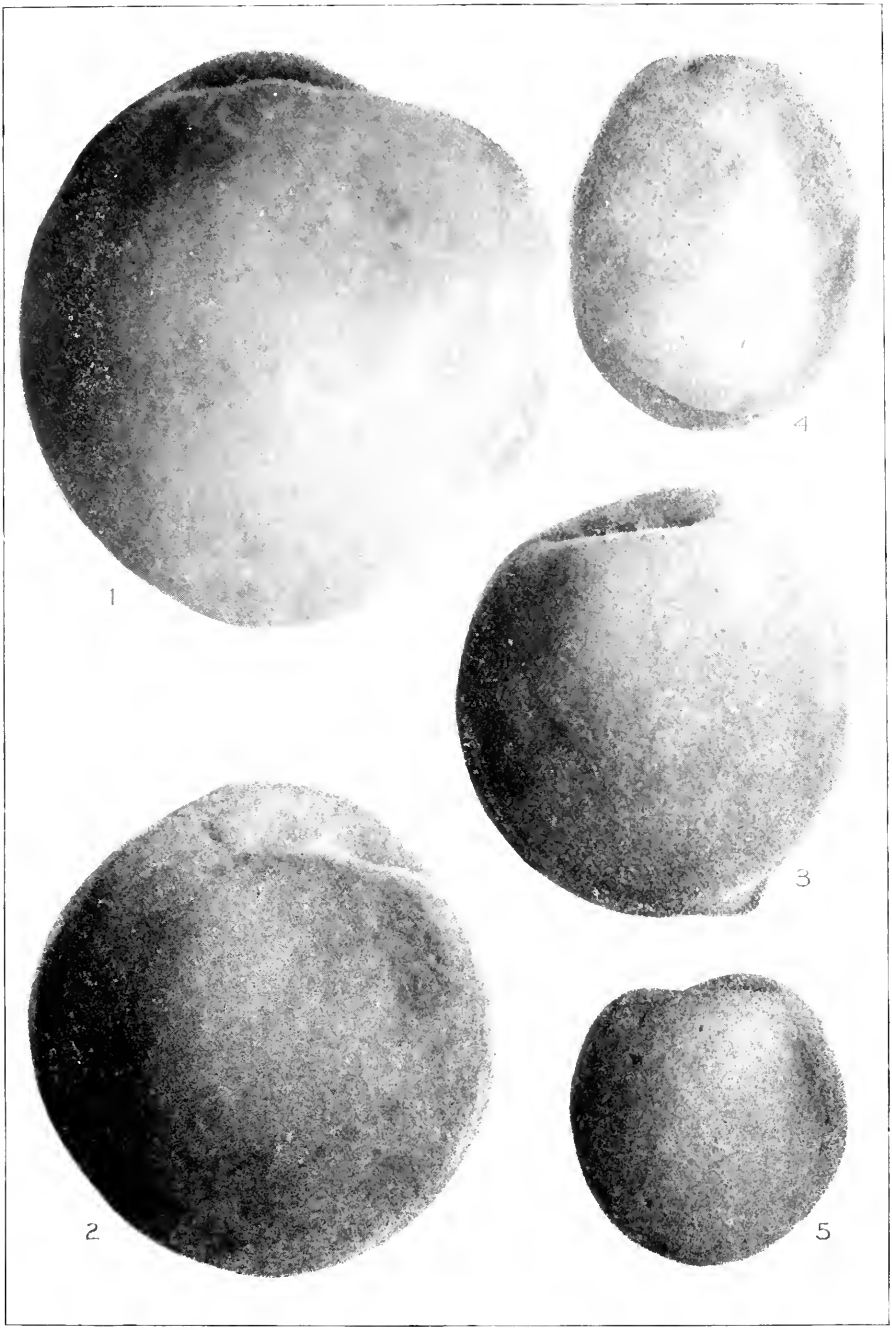


PLATE III.—1, PERFECT PEACH; 2-5, IMPERFECTLY FERTILIZED PEACHES.

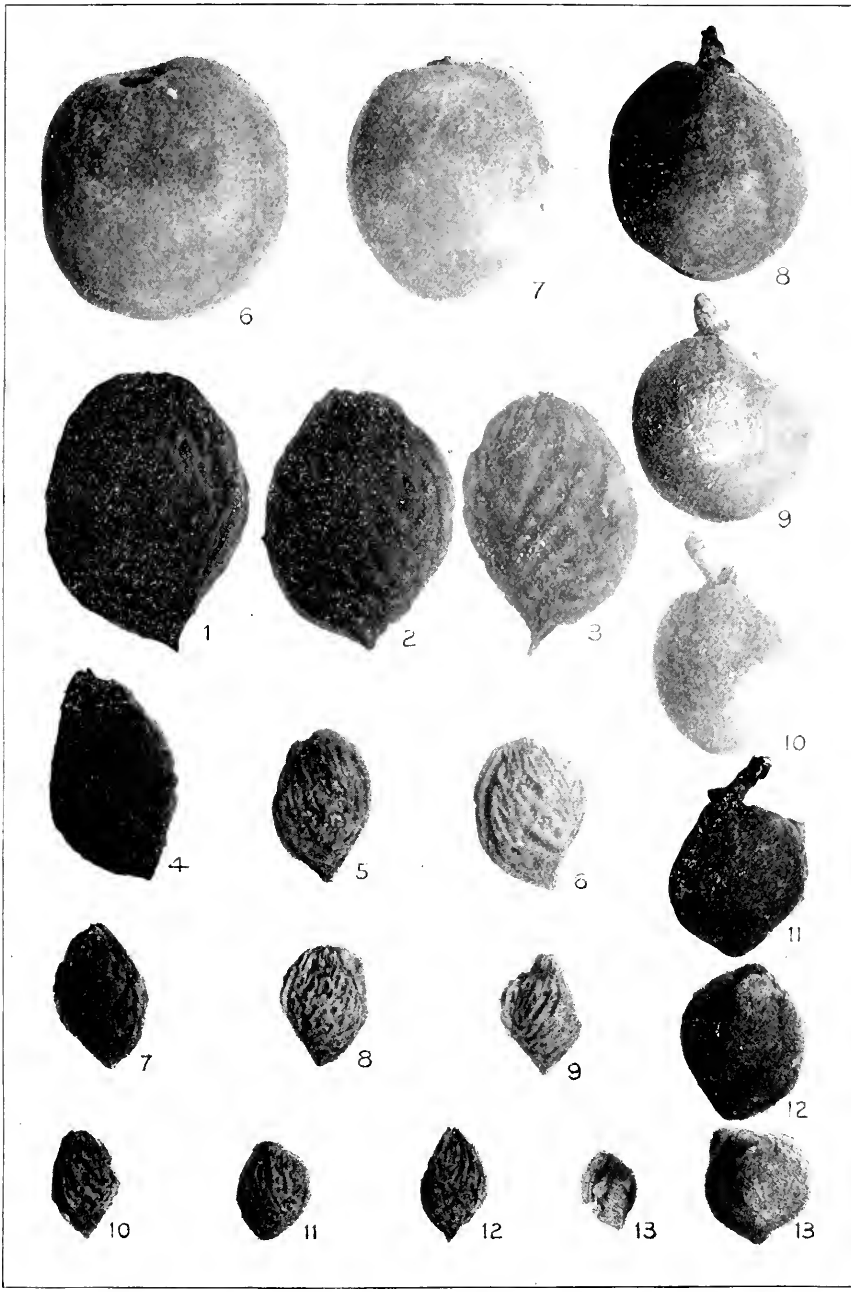


PLATE IV.—IMPERFECTLY FERTILIZED PEACHES; WITH PITS FROM PERFECT AND IMPERFECT FERTILIZATION.

Plate V.—Imperfectly Fertilized Peaches.

When a tree is affected with "little peach" all of the fruits on any given branch are affected and are fairly uniform in size; whereas, in the case under consideration, a normal fruit and small fruits of various sizes may be found on the same small branch. (Plate II.)

There are other important differences between "little peach" disease and the effects of imperfect fertilization; but the two above stated are sufficient to enable anyone to distinguish between them. It is important for fruit growers to note these differences. Trees affected with "little peach" should be promptly removed. They do not recover and it is possible that they may be a source of infection to healthy trees. Imperfect fertilization, on the contrary, is certainly not infectious, and trees seriously affected one season may bear a full crop the following season. Consequently, it would be unwise to destroy trees because of imperfect fertilization.

Mr. G. Hiester,[5] writing in the *Country Gentleman* for November 24, 1898, states that in 1896 his orchard of 3,000 trees bore a crop of imperfectly fertilized peaches. The following year the same trees gave "an abundant crop of perfect peaches." Evidently Mr. Hiester had to do with a case similar to that observed by us at Penn Yan, but he makes the serious mistake of confusing it with the "little peach" disease.

Another case of imperfect fertilization was observed in a peach orchard near Geneva. On the east side of the orchard there were six rows of the variety Crosby and on the opposite side six other rows of the same variety. Between the two blocks of Crosby there were several rows of Brigdon and Red Cheek Melocoton. The Crosby was so much affected with imperfect fertilization that the yield was only about one-sixth of a full crop; while the other two varieties were affected but little. According to the foreman in charge, the Crosbys were similarly, but not so much, affected in 1900.

---

[5] Hiester, Gabriel. The Cause of Little Peaches. *Country Gent.*, 63:928. 24 N. 1898.

V. TILE DRAIN CLOGGED BY FUNGUS.

On June 13, 1901, while investigating an outbreak of currant anthracnose in the vicinity of Milton, we met Mr. H. H. Hallock, a vinegar manufacturer of that place. Mr. Hallock informed us that the tile drain to his vinegar cellar had become clogged some time during the previous May and upon investigation he had found that the cause of the trouble was a fungous growth resembling the "mother" of vinegar. He removed some of the tiles at intervals of about twenty-five feet and laboriously poked out the fungus until the drain was clear. In about three weeks it clogged again. Knowing the destructive effect of copper sulphate on fungi in general it occurred to him to try to remove the fungus by putting some of the chemical into the upper end of the drain. Accordingly, this was done. About one-fourth pound of copper sulphate crystals was placed in the upper end of the drain on Saturday. The following Monday it was found that a large quantity of the fungus had been discharged from the outlet and the drain was again clear. However, in a few days it clogged for the third time, and the copper sulphate treatment was applied again with beneficial results. Fully one-half barrel of the fungus was discharged. This was about June 10. During the remainder of the season the fungus gave no further trouble.

Our visit on June 13 was timely. A large quantity of the fungus lay in a pool of water at the mouth of the drain where it could be readily examined. It consisted of brownish, ropy, slippery masses of various sizes somewhat resembling the so called "mother" of vinegar. A small quantity was obtained for microscopic examination. It was found to consist almost exclusively of hyphæ having a diameter of 8 to 11 μ. Some of the hyphæ were almost wholly destitute of contents, while others contained brownish granules which gave the brownish tinge in mass. The hyphæ were sparingly branched in a dichotomous fashion. At regular intervals they were sharply constricted and at each constriction there was a single spherical

body, steel blue in color and having a diameter slightly less than that of the hypha. On account of the presence of these bodies it was not easy to determine whether there were septa at the points of constriction, but it was finally decided that the hyphæ were non-septate. No sign of fructification was present.

After a vain endeavor to determine the fungus it was submitted to Prof. Geo. F. Atkinson, who at once identified it as *Leptomitus lacteus* Ag. With the name of the fungus known, its literature became accessible and it was learned that the fungus is one which lives in water contaminated with organic matter. In the present case it was feeding upon the small quantity of cider drained from the floor of the vinegar cellar. Humphrey[6] reports its occurrence at Bridgeport, Conn., in a stream below a tripe house; and Gœppert[7] observed it growing in a small stream below a beet-molasses manufactory near Schweidnitz, in Silesia. Humphrey[8] states that in his studies "it appeared in fly cultures from waters from the outlets of drains containing decaying vegetable matter;" but so far as we can learn it has not been previously reported troublesome in drains except, perhaps, in a single instance. In the *Country Gentleman* (Vol. 61, p. 406) for May 21, 1896, there is a short article headed, "Fungus in Drain." In this article C. W. B[eak] of South Onondaga, N. Y., gives an account of the clogging of his barnyard drain by "a thick scum—looks like the 'mother' in vinegar." By correspondence with Mr. Beak we have obtained additional details of the case and it appears probable that the cause of the trouble was *Leptomitus lacteus*.

The spherical bodies at the points of constriction in the hyphæ are so constant and so characteristic that they should serve as a mark of identification.[9] (Plate VI, Fig. 1). They

---

[6] Humphrey, J. E. The Saprolegniaceæ of the United States, with Notes on Other Species. *Trans. Am. Phil. Soc.*, 17 (III):136.

[7] Gœppert, H. R. Ueber Leptomitus lacteus in der Weistritz. *Ber. d. Schles. Gesellsch. f. vaterl. Cultur*, 1852, p. 54. (Reference taken from Humphrey.)

[8] Loc. cit., p. 135.

[9] In all of the material examined by us the cellulin grains (cellulinkörner) were found almost invariably at the points of constriction.

prove to be the "Cellulinkörner" of Pringsheim.[10] According to Pringsheim[11] they are not homogeneous in structure, but show stratification. At first we did not notice this, but upon closer inspection it was found to be true.

Before our study of the fungus was finished and before camera-lucida drawings had been made the fungus decayed and it was found impossible to obtain more of it. About October 7 the drain became clogged and Mr. Hallock, thinking that probably the fungus was the cause, applied copper sulphate as before. But this time the remedy did not work and upon investigation it was found that rats had removed the wire screen from the upper end of the drain, thereby permitting the ingress of sticks and rubbish. When the obstruction was finally removed a small quantity of light brown fungus came away with it. While to the unaided eye this fungus bore some resemblance to the fungus which had clogged the drain in June, the microscope revealed the fact that it was quite a different thing. It was a mixture, chiefly of two kinds of fungi: (1) A fungus with large hyphæ bearing a striking resemblance to Rhizoctonia. They had a brownish tinge, usually branched at right angles, the branches somewhat constricted at the point of departure and with the first septum at a distance from the wall of the parent hypha. (Plate VI, Fig. 2.) However, the septa were not clearly defined and in many cases it was uncertain whether any real septa existed. The diameter of the hyphæ varied from 12

Occasionally a constriction was without a cellulin grain and sometimes cellulin grains were found elsewhere than at the constrictions; but, as a rule, there was a single cellulin grain at each constriction. However, it appears that this condition of affairs is not to be expected in all cases, and may, perhaps, be the exception rather than the rule. Humphrey [*Trans. Am. Phil. Soc.*, 17 (III):69], in speaking of cellulin grains, says: "In *L. lacteus* they *often* become lodged in constrictions of the hyphæ." He also cites Rothert's observation that they may *disappear* during the formation of sporangia. Pringsheim's figures (*Ber. d. deutsch. bot. Gesellsch.*, 1, Taf. VII, Figs. 1–9) show the cellulin grains distributed seemingly without reference to the constrictions.

[10] Pringsheim, N. Ueber Cellulinkörner, eine Modification der Cellulose in Körnerform. *Ber. d. deutsch. bot. Gesellschaft*, 1:288–308. Mit Tafel VII.

[11] Loc. cit.

to 24 μ, the most common size being 15 μ: (2) A fungus with unbranched, colorless, seemingly non-septate hyphæ having a diameter of about 2 μ. (Plate VI, Fig. 3.) Neither fungus showed any fructification and neither one was determined.

Subsequently to our study of the fungus in June Mr. Hallock[12] prepared for publication a brief article on the subject, which appeared in the *Rural New Yorker* for July 27, 1901. In addition to the circumstances which we have already related, he states that the tile drain was put into place in the autumn of 1900 to replace a stone drain which, although it had not run as freely as it should, had, nevertheless, never become completely clogged during the several years in which it was in operation. The new tile drain was made of three-inch porous tiles and worked all right during the fall and winter, but clogged in the spring at a time when there was plenty of rain to keep the drain flushed out. In the fall, at cider making time, considerable pomace is run off through the drain, and had it clogged at that time it would have been less strange.

In this connection it is interesting to note that Mr. Beak's barnyard drain at South Onondaga had been in place fifteen years before it became clogged. He removed the fungus by mechanical means. In his recent letter to us he states that he did not use the sulphuric acid recommended by the *Country Gentleman*; neither did he use any other chemical, and yet the drain has not clogged since the spring of 1896. Last spring he again saw indications of the presence of the fungus, but by turning a large quantity of water into the upper end of the drain he succeeded in washing out the fungus and prevented clogging.

Mr. Hallock's method of clearing his drain of fungus by the use of copper sulphate is so simple and so cheap that it is worthy of recommendation in all cases of this kind. Sulphuric acid, carbolic acid and other strong chemicals are also destructive to fungi and may, perhaps, answer equally well.

We think it likely that the clogging of drains by fungus may be more common than is generally known.

---

[12] H[allock], H. H. Blue Vitriol Cleans a Drain. *Rural New Yorker*, 60:515.

EXPLANATION OF PLATE VI.

FIG. 1. Leptomitus lacteus *from tile drain;* a, *a cellulin grain;*

FIG. 2. *Large hyphæ from tile drain. Magnification 225 diameters;*

FIG. 3. *Small hypha from tile drain. Magnification 1060 diameters;*

FIGS. 4–8. *Refrigerator fungus:* 4, *a living hypha;* 5, *four spores (?);* 6, *portion of a hypha with forming spore borne laterally;* 7, *portion of a hypha with spore borne terminally;* 8, *hyphæ after four months in formalin. Magnification 650 diameters.*

NOTE.—Figs. 2–8 *made with the aid of a camera-lucida. Fig. 1, diagrammatic.*

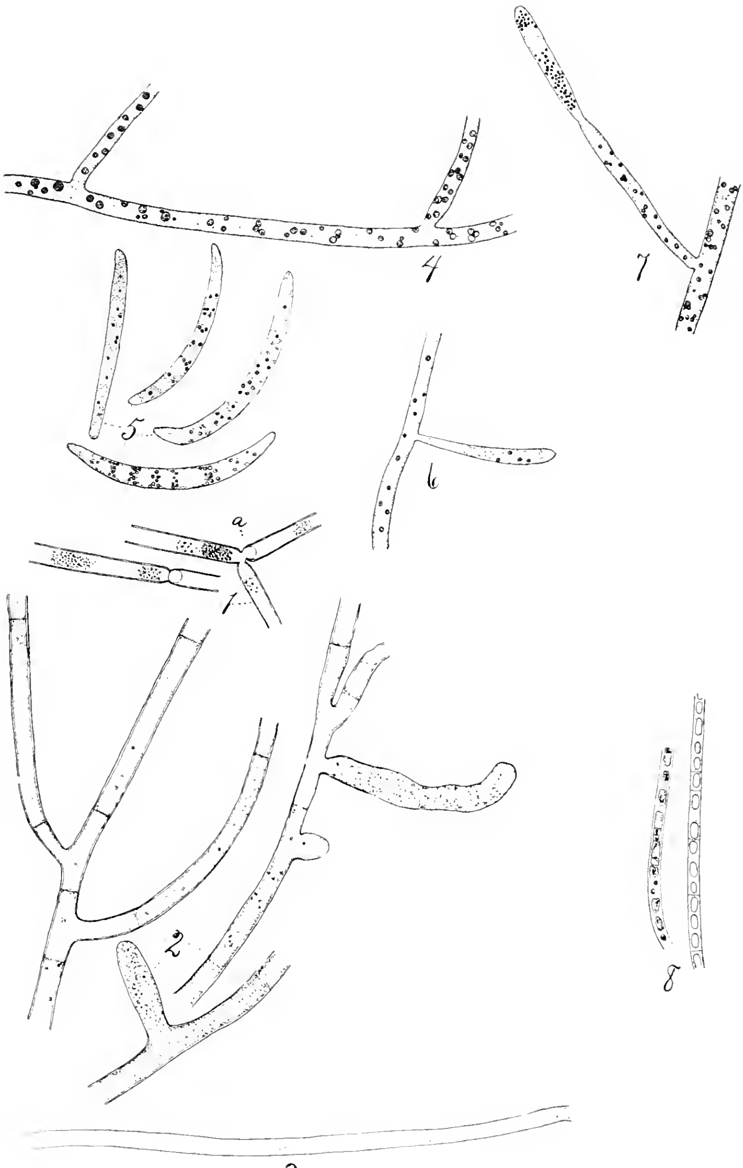


PLATE VI.—FUNGI FROM TILE DRAIN AND REFRIGERATOR.

VI. A FUNGUS IN REFRIGERATORS.

Last July our attention was called to a refrigerator which was not working properly. The provision compartment was flooded with water. Upon investigation it was found that the drain pipe was plugged throughout its entire length with a fungous growth. The conical cap over the lower end of the drain pipe was likewise filled with it, as was also the tube of a large funnel set to catch the water and conduct it through the floor.

Being, at that time, interested in the tile drain fungus discussed in the preceding article, we at once became interested in this somewhat analogous case and decided to make a study of it.

The fungous growth was gray or dirty gray in color; but on account of admixture with dirt from the ice some of it was quite dark. It had a slimy, slippery feel and clung together in sheets or rope-like masses which were often several inches in extent. Microscopic examination showed the slimy, gray masses to be composed of small, uncolored fungous hyphæ loosely woven together. The hyphæ were branched and had a diameter of 3 to 5 μ. They contained numerous roundish granules of various sizes, and appeared to be non-septate. The most striking character of the fungus was the presence of curved spore-like bodies resembling the spores of *Fusarium* except that they were non-septate. They measured 28 to 43 μ in length by $4\frac{1}{2}\mu$ in width. They were abundant and most of them were free, but occasionally they were found attached to the hyphæ both laterally and terminally (Plate VI, Figs. 4–8). We have been unable to identify the fungus. In the fresh condition we were unable to find any traces of septation, either in the hyphæ or spores; but after the fungus had been preserved four months in a 4 per ct. soluion of formalin, some of the hyphæ had the appearance of being septate (Plate VI, Fig. 8). However, the small size of the hyphæ makes it difficult to determine this point with certainty; therefore, the identity of the fungus is very uncertain. If the hyphæ are really non-septate (and we incline to this opinion) the fungus belongs to the Phycomyceteæ, a group which contains many

species of water-inhabiting fungi. On the other hand, if the hyphæ are septate it belongs either to *Fusarium* or *Fusisporium*, and the species of these genera rarely live in water.

It appears that this gray, slimy fungus is of common occurrence and wide distribution in refrigerators. Upon inquiry among the members of the Station staff it was found that several of them are familiar with the fungus. Five of them furnished us with samples, all of which proved to be identical with the original sample. In each case the fungus with small, colorless hyphæ and curved spores was found to predominate. Sometimes traces of other fungi, Oscillaria and bacteria were found but never in quantity. It is plain that the chief culprit is the fungus above described. Mr. Harding, the Station Bacteriologist, informs us that while he was an assistant in the bacteriological laboratory of the University of Wisconsin a refrigerator kept in the laboratory clogged at frequent intervals with a fungus probably the same as that found by us.

Correspondence with some firms manufacturing refrigerators indicate that the trouble is a general one. The Wilke Manufacturing Co., Anderson, Ind., write as follows: "Replying to yours of the 15th, we have encountered, in a commercial way, the fungus growth to which you refer. We have always referred to it as 'slime from the melted ice.' It is a peculiar deposit or growth, and will in time choke up the drain pipe. There seems to be little or no difference whether the ice is natural or artificial—from distilled water. In our Instruction Card, which accompanies each refrigerator, we refer to this 'slime' and request the users to remove drain pipe and scald it at least once a month during the summer season."

The Bowen Manufacturing Co., Fond du Lac, Wis., write: "Our attention has at times been called to clogged drain pipes, which on being emptied proved to be filled with a substance having the appearance of jelly, with firmness enough to hold together in lengths of several inches. We had never looked upon this as a fungus growth, but rather as gelatinous matter coming from the ice, or condensed from the vapors which arise from the articles placed in the provision compartment."

In this connection we will call attention to a popular error concerning the origin of the "slime." In the main, it is a *growth* and not a *deposit* or accumulation of matter from the melted ice. In all probability the trouble originates with the ice; that is, the ice contains spores or fragments of the fungus which, upon the melting of the ice, become lodged in the drain pipe and then commence to grow and multiply to an enormous extent. In all cases coming under our observation the principal part of the obstruction has been made up in this way; but if there is dirt or other foreign matter in the ice it lodges with the fungus and adds to its bulk. The nourishment of the fungus consists, chiefly, of waste material from food placed in the ice chamber. With many housewives it is a common practice to use the ice chamber for storing provisions whenever the provision compartment becomes crowded. As a consequence, milk, meat juices, particles of butter, etc., find their way into the drain pipe to furnish nourishment for the fungus growing there.

In one of the letters quoted above it is stated that it seems to make little difference whether the ice used is natural or manufactured. This needs explanation. Ice made from distilled water cannot contain the germs of the fungus and if used in a new refrigerator there would probably be no trouble with slime in the drain pipe. But a change from natural ice to manufactured ice will not result in the disappearance of the slime unless the precaution is taken to thoroughly disinfect the drain pipe and the ice chamber. Otherwise, the fungus contiues to grow as before, because the drain pipe is already "seeded" with the fungus before the manufactured ice comes into use.

The presence of the fungus should not be regarded as evidence that the ice is dangerously impure. A mere trace of the fungus in the ice may bring about a luxuriant growth in the drain pipe.

The simplest and most effective way of getting rid of the fungus is to occasionally wash out the drain pipe and ice chamber with boiling water.

REPORT

OF THE

Chemical Department.

L. L. VAN SLYKE, *Chemist.*

C. G. JENTER, *Assistant Chemist.*

W. H. ANDREWS, *Assistant Chemist.*

J. A. LE CLERC,[1] *Assistant Chemist.*

F. D. FULLER, *Assistant Chemist.*

E. B. HART, *Assistant Chemist.*

C. W. MUDGE, *Assistant Chemist.*

A. J. PATTEN, *Assistant Chemist.*

TABLE OF CONTENTS.

---

[1] Absent on leave after September 1, 1901.

A STUDY OF ENZYMES IN CHEESE.*

L. L. VAN SLYKE, H. A. HARDING AND E. B. HART.

SUMMARY.

I. Introduction.—Cheddar cheese contains enzymes coming from (1) bacteria, (2) milk glands of cows and (3) rennet. These enzymes, or chemical ferments, change insoluble cheese-casein into soluble nitrogen-compounds. The investigation has aimed to exclude bacterial action in cheese and limit the action to results produced by enzymes present in milk when made into cheese.

II. Historical outline.—Early work done to show whether enzymes were active in cheese ripening gave negative results, owing to faulty methods of investigation. Babcock and Russell furnished the first positive evidence in 1897 in the discovery of the enzyme galactase in milk. They and others have also shown the power of rennet-enzymes to render cheese-casein soluble.

III. Methods of chemical analysis used.—Outlines are given to show methods used in determining total nitrogen, water-soluble nitrogen and nitrogen in forms such as albumoses, peptones, amides and ammonia; also method of determining chloroform in cheese. In milk, the term soluble nitrogen includes all nitrogen-compounds except casein and albumin; in cheese, it includes all the nitrogen soluble in water under the conditions indicated.

IV. Effect of chloroform, ether and formalin on the action of enzymes.—(1) The effect of quantities of chloroform, varying from $2\frac{1}{2}$ to 30 per ct. in milk, covering a period of 192 days, is shown to be apparently small in respect to restraining enzyme action. (2) It is shown that increase of fat in a mixture has little or no

*A reprint of Bulletin No. 203.

effect upon the antiseptic value of chloroform. (3) Chloroform is shown to be somewhat more effective in repressing bacterial activity than ether or a mixture of chloroform and ether, without interfering with enzyme action. (4) Formalin appears to restrain enzyme activity much more than does chloroform.

V. Connection between bacteria in the udder and enzymes in the milk.—Examination of milk drawn from different quarters of the udder with all necessary precautions shows that there is an apparent relation between the number of bacteria in the udder and the rapidity with which soluble nitrogen-compounds are formed in the milk.

VI. Ripening process in normal cheese and in cheese made with chloroform.—(1) Method of manufacture. Chloroform is introduced into milk at beginning of operation of cheese-making, using 4 or 5 per ct. of chloroform for the milk employed. The cheese thus made contains 12 to 15 per ct. of chloroform. It is then kept in an atmosphere of chloroform. All bacterial action can thus be prevented. (2) Chemical changes in cheese under chloroform compared with the normal cheese. In normal cheese, more soluble nitrogen is formed than in cheese made and cured with chloroform; the soluble nitrogen at the end of a year being about 37 per ct. in normal cheese and less than 23 per ct. in chloroform cheese. The amount of soluble nitrogen formed in chloroform cheese is regarded as representing work done by enzymes present in the milk when made into cheese. (3) Influence of acid upon enzyme action. Two-tenths of one per ct. of lactic acid added in the operation of making cheese with chloroform increased the amount of soluble nitrogen in a marked degree. (4) The use of salt retards the ripening of cheese to a degree quite marked. (5) Difference in character of chemical change in normal and in chloroform cheese. (a) In normal cheese the proportion of amides is large in comparison with albumoses and peptones. In chloroform cheese the reverse is true. (b) In chloroform cheese little or no ammonia is formed, while in normal cheese ammonia appears early and increases steadily.

I. INTRODUCTION.

Fermentation, or the breaking down of complex organic compounds into simpler ones, was first looked upon as a purely chemical process. Later it was studied from the standpoint of germ life and now we are coming to see that most of the work of fermentation is accomplished by the action of unorganized ferments commonly called enzymes. Enzymes are chemical substances, without life, capable of causing deep-seated changes in certain substances, the enzymes themselves undergoing little or no change. They are produced by the activity of plant or animal cells.

As we shall see, Cheddar cheese as ordinarily manufactured, contains enzymes derived from three sources—(1) bacteria, (2) milk glands of cows and (3) rennet.

During the past three years, in which we have constantly been working upon the problem of cheese ripening, it has been our hope to determine what proportion of the casein decomposition in normal cheese can be justly ascribed to the activity of enzymes. A direct determination under normal conditions is rendered impossible by the continued activity of germ life within the cheese mass. A separation of the activities of the various groups of enzymes is also rendered difficult under ordinary circumstances, owing to the intimate way in which the enzymes are mingled during the process of manufacture.

Work on these lines is going forward under more satisfactory conditions than before and this report is to be considered only as a record of a portion of the data secured.

The difficulties attending an investigation of this kind have been reduced to a minimum by the convenient location of all the departments and supplies concerned in the work. Our bacteriological laboratory, cheese-curing rooms and dairy are in one building, while the chemical laboratory and the cattle barns are only a few rods distant.

In making the cheese used in our investigation, we have had the valuable assistance of Mr. George A. Smith, Dairy Expert,

Mr. L. A. Rogers, Assistant Bacteriologist, has done much of the routine work connected with the bacteriological examinations. Mr. J. A. Le Clerc and Mr. A. J. Patten have rendered efficient assistance in some of the chemical work.

II. HISTORICAL OUTLINE.

The following outline of the work previously done in relation to cheese ripening covers only those features that relate to the special problems we have been studying.

In 1887, Benecke,[1] in discussing the rôle of bacteria in cheese ripening, stated that, while they probably caused such changes, yet the ripening might really be due to the activity of some unorganized ferment. He pointed out that, if bacteria are not essential to cheese ripening, this fact could be made clear by the preparation of cheese under conditions which would exclude bacterial activity. Acting on this suggestion Adametz[2] prepared a number of *Hauskäse*, a form of soft cheese, in the normal way, except that he added various disinfectants to the milk or to the curd derived from it.

When cheese made with the addition of kreolin or of thymole, were examined bacteriologically, they were pronounced sterile; but even when kept for double the normal length of time, they did not take on the appearance of ripened cheese. His experiments with salicylic acid, oxalic acid and with vapors of carbon disulphide and iodine were less satisfactory in repressing the microörganisms in the cheese, but these agents seemed to hold back the ripening in proportion as they inhibited the activity of germ life.

Cheese investigators quite generally accepted these results as settling the point raised by Benecke, and during the succeeding ten years the work on cheese ripening was based upon the theory of germ action.

The phenomena of ripening in cheese may be divided into two classes, (1) the chemical decomposition of casein and (2) the for-

[1] Benecke. Cent. f. Bak., I Abt., 1:521 (1887).
[2] Adametz. Thiel's Landwirtschaftliche Jahrb., 18:227 (1889).

mation of cheese flavors. These may or may not arise from common causes. The casein begins to undergo change at once, while the formation of flavors begins some time later, after which the two progress simultaneously. These two groups of phenomena cannot be measured by the same means or standards.

Duclaux, Adametz, Weigmann and their disciples have directed their attention to the formation of flavors and have quite generally relied upon the odor and physical appearance of their material in judging of the rate and character of the ripening. In those cases in which they have gone more fully into the solubility of the casein, they have usually determined this point by its ability to pass through a porcelain filter, a method which von Freudenrich & Jensen[3] have shown to be extremely liable to error in practice. They have rarely attempted to show that the species of bacteria which they look upon as the causal ones are present in cheese in any considerable quantities. They have, for the most part, confined themselves to showing that pure cultures of these species are able, by means of excreted enzymes, to digest the casein of milk and at the same time to form cheese-like odors. In some cases they have made cheese with the addition of pure cultures or of solutions of their enzymes and have stated that the resulting product was better flavored than cheese made in the usual way. In establishing this point, however, they were handicapped by the lack of accurate standards for measuring such relations.

Recently Adametz and Winkler[4] have placed a culture of one of these bacilli upon the market under the trade name of "Tyrogène," its use being expected to result in the production of a desirable Emmenthaler flavor in cheese. Some preliminary tests by von Freudenrich[5] have failed to indicate that it will accomplish this desired end.

When the study of the kinds of bacteria present in cheese was extended so as to include the numbers of each kind, it was found that the enzyme-forming bacteria previously mentioned

[3] v. Freudenreich and Jensen. Landw. Jahrb. d. Schweiz., 14:169 (1899).
[4] Winkler. Molkerei Ztg., 14:817 (1900).
[5] v. Freudenreich. Ann. Agr. Suisse (1901).

were present only in small numbers. Even when large numbers were added to milk before making it into cheese, these bacteria ceased to grow almost as soon as the curd was put into the press and rapidly disappeared in the cheese.

It was found that from the time cheese was made until fully ripened there were present few besides *lactic acid* bacteria, so called because they curdle milk by production of acid without subsequent digestion of the casein. From these results von Freudenreich was led to question the connection between enzyme-forming bacteria and ripening process. He made numerous attempts to produce cheese with the addition of cultures of enzyme-forming bacteria, which uniformly resulted in a product of poorer flavor, according to his opinion. He then became the champion of the theory that lactic acid bacteria are the principal, if not the only, cause of cheese ripening.[6]

The chief objection to this theory is the fact that no one has yet been able to demonstrate the production of an enzyme on the part of lactic acid bacteria. Without such aid it is difficult to understand how a becterium is to attack an insoluble substance such as the coagulated casein in cheese.

Von Freudenreich[7] added chalk to milk cultures of these lactic acid bacteria for the purpose of preventing the accumulation of acid and of simulating in this respect the conditions found in cheese. He was thus able to demonstrate the ability of these organisms to increase materially the amount of soluble nitrogen. However, Chodat and Hoffman-Bang[8] have pointed out that this is not equivalent to attacking the casein after it has been coagulated by rennet. They maintain that lactic acid becteria are unable to attack coagulated casein, even when sugar is not present.

In a later publication Jensen,[9] without bringing forward adequate experimental evidence, has suggested that lactic acid bacteria are able to elaborate an enzyme.

[6] v. Freudenreich. Cent. f. Bak., II Abt., 1:384 (1895).
[7] v. Freudenreich. Cent. f. Bak., II Abt., 3:231 (1897).
[8] Chodat and Hoffman-Bang. Ann. Inst. Pasteur, 15:36 (1901).
[9] Jensen. Landw. Jahrb. d. Schweiz., 14:197 (1900).

In 1897 Babcock & Russell[10] announced that the milk of all mammals contains, in addition to the previously known substances, *galactase*, a tryptic-like ferment capable of producing digestion of casein, and they suggested that this substance might play a considerable role in cheese ripening. The correctness of their statements regarding the existence of this substance has been substantiated by Storch,[11] von Freudenreich[12] and Jensen.[13]

In 1901 Babcock, Russell and Vivian[14] and Jensen[15] almost simultaneously called attention to the ability of pepsin, contained in rennet solution, to render casein soluble, and they presented experimental evidence to establish this point.

Thus, we see that cheese, as ordinarily manufactured, contains enzymes derived from three different sources, (1) bacteria, (2) milk glands of cows and (3) rennet.

Enzymes, in acting upon casein, cause its decomposition and probably produce compounds that furnish some of the cheese flavors. While we appreciate as highly important, from a practical standpoint, the study of cheese flavors, we have devoted our time chiefly to a study of enzyme action upon cheese-casein. It seems that this constitutes so fundamental a problem in cheese ripening that it should be first studied, and moreover its solution will doubtless go far toward solving the problem of flavors.

III. METHODS OF CHEMICAL ANALYSIS USED.

In a later bulletin the methods of chemical analysis used in determining the amounts of nitrogen present in different forms in cheese will be presented and discussed in full detail. In this connection it seems sufficient to present only a brief outline of such methods.

---

[10] Babcock and Russell Ann. Rept. Wis. Exp. Sta. 14:161 (1897).

[11] Storch. 40 Rept. Copenhagen Exp. Sta. (Denmark).

[12] v. Freudenreich. Cent. f. Bak., II Abt., 5:241 (1899).

[13] Jensen. See footnote 9.

[14] Babcock, Russell and Vivian. Ann. Rept. Wis. Exp. Sta. 17:102 (1900), also Cent. f. Bak., II Abt., 6:817 (1900).

[15] Jensen. Landw. Jahrb. d. Schweiz., 14:197 (1900), also Cent. f. Bak., II Abt., 6:734 (1900).

PREPARATION OF CHEESE EXTRACT.

Twenty-five grams of cheese are mixed with quartz sand and treated at 122° to 140° F. (50° to 60° C.) for a half hour with each of several successive portions of water, decanting and filtering each portion of extract until 500 cc. have been accummulated. Portions of the solution thus prepared are used in making the various determinations.

DETERMINATION OF NITROGEN-COMPOUNDS IN CHEESE EXTRACTS.

(a) *Total water-soluble nitrogen* is determined in an aliquot part of the water extract.

(b) *Precipitation by alum.*—To 100 cc. of water extract, 2 cc. of saturated alum solution are added and digested at 104° to 108° F. (40° to 42° C.) until precipitation is complete. The precipitate is filtered, washed and then treated by Kjeldahl method to determine nitrogen.

(c) *Coagulation by neutralizing and boiling.*—The clear filtrate from (b) is exactly neutralized by dilute fixed alkali and heated on water bath until coagulation is complete. The precipitate is filtered, washed and its nitrogen determined by Kjeldahl method.

(d) *Albumoses.*—To the filtrate from (c) two or three drops of dilute (one to three) sulphuric acid are added, and then powdered zinc sulphate to saturation. The mixture is heated on water bath until precipitation is complete and the nitrogen is determined in the precipitate washed with saturated solution of zinc sulphate.

(e) *Peptones.*—To the filtrate of (d) two or three drops of strong hydrochloric acid are added and then bromine in successive portions of a few drops at a time, accompanied by vigorous shaking until the liquid becomes super-saturated. The nitrogen in the washed precipitate is determined as before.

(f) *Amides.*—(1) First Method. The nitrogen in filtrate from (e) is determined directly by Kjeldahl method and this, less the nitrogen present as ammonia, is the amide nitrogen.

(2) Second Method. To 100 cc. of the original cheese extract

there is added about one gram of common salt, together with an excess of ten per ct. tannic acid solution. The precipitate formed is filtered and washed and the nitrogen determined in an aliquot part of the filtrate. From this amount of nitrogen is deducted the amount of nitrogen found as ammonia in (g) and the remainder is the amount of amide nitrogen.

(g) *Ammonia.*—To an aliquot portion of the filtrate obtained in (f), magnesium oxide is added and the ammonia separated by distillation.

DETERMINATION OF NITROGEN-COMPOUNDS IN MILK.

Casein.—To 20 gms. of milk, diluted with water to about 100 cc., are added 2 to 2½ cc. of saturated alum solution. The determination is completed as under (b) in cheese extract, and the other determinations are made as described above in the cheese extract.

DETERMINATION OF CHLOROFORM IN CHEESE AND MILK.

About 5 gms. of milk or cheese are placed in a pressure bottle with about 10 cc. of alcohol and 5 gms. caustic potash. The bottle and contents are then heated 30 minutes at 230° F. (110° C.) in an autoclave. The resulting chloride is determined volumetrically as in case of chlorine in sodium chloride.

FORM OF STATING RESULTS.

The figures given in the various tables represent percentages of the total nitrogen in milk and cheese. This form of statement is usually preferable, as figures representing the actual percentages in milk and cheese are often very small. Hence, considerable variations, expressed in percentages of nitrogen, often represent very small variations when expressed in actual amounts present in cheese and milk.

The soluble nitrogen in milk, as used in this bulletin, includes all nitrogen compounds except casein and albumin. The water-soluble nitrogen in cheese includes all the nitrogen soluble under the conditions indicated in preparing the water extract of cheese.

IV. EFFECT OF CHLOROFORM, ETHER AND FORMALIN ON THE ACTION OF ENZYMES.

In an investigation of this kind a prime necessity is a means of totally suppressing the action of germ life. It is equally important that the action of the agents employed shall not be so violent as to alter the enzymes or the casein.

The work of Babcock and Russell has suggested two substances suitable for this purpose, ether and chloroform. Of the two we have used chloroform almost exclusively for several reasons: (1) As an anæsthetic it is more efficient; (2) its proportion in any mixture can be quantitatively determined with approximate accuracy by chemical analysis; (3) the amount required to prevent germ growth does not so largely increase the bulk of the mixture; (4) being less volatile, there is less loss in sampling materials under investigation; (5) it is not inflammable.

In all our work with solutions it has been our aim to mix carefully by shaking at least once a day during the entire course of the experiment. Too much stress cannot be laid upon this point, since mixtures of milk with ether or chloroform tend to separate on standing and thereby produce conditions favoring the germination of spores in certain portions of the mixture.

EFFECT OF VARYING PERCENTAGES OF CHLOROFORM ON ENZYME ACTIVITY.

Since the relation of chloroform to the activity of these enzymes has not been investigated, except in a very general way by Babcock and Russell, the following study of its action on galactase and bacterial enzymes was made.

Duplicate bottles of separator skim-milk containing only a trace of fat were prepared containing 2.5, 5, 10, 20 and 30 per ct. of chloroform by volume. These bottles were kept at 60° F. (15.5° C.), and examined both chemically and bacteriologically.

TABLE I.—INFLUENCE OF VARYING AMOUNTS OF CHLOROFORM UPON THE ACTIVITY OF ENZYMES.

Amount of chloroform.	Age.	In 100 lbs. total nitrogen. Total soluble nitrogen.	Nitrogen in albumoses and peptones.	Nitrogen in amides.	No. of germs per cc.
Per ct.	*Days.*	*Lbs.*	*Lbs.*	*Lbs.*	
	fresh	9.33	4.58	4.75	———
2.5	7	11.60	6.81	4.79	28
5	7	11.63	6.94	4.69	46
10	7	11.72	7.07	4.65	26
20	7	11.63	6.79	4.84	25
30	7	12.28	7.37	4.91	18
2.5	21	16.80	9.94	6.86	42
5	21	16.16	8.47	7.69	36
10	21	16.39	8.99	7.40	25
20	21	16.37	8.34	8.03	26
30	21	13.69	7.07	6.62	30
2.5	49	21.79	14.75	7.03	———
5	49	21.65	14.63	7.02	———
10	49	21.40	14.93	6.47	———
20	49	20.11	14.36	5.75	———
30	49	22.99	16.17	6.82	———
2.5	112	33.15	18.81	14.34	9
5	112	33.62	18.59	15.03	10
10	112	30.51	16.38	14.13	11
20	112	33.78	16.39	17.39	6
30	112	33.06	19.15	13.91	5
2.5	192	41.98	19.18	22.80	13
5	192	39.37	14.85	24.52	14
10	192	35.36	15.13	20.23	7
20	192	35.65	16.37	19.28	6
30	192	35.78	17.30	18.48	———

During 112 days the amount of soluble nitrogen varied within very narrow limits in the different bottles. During the next 80 days the bottles containing 2.5 and 5 per ct. of chloroform showed a little more soluble nitrogen than the others, in which the amounts of soluble nitrogen were almost identical. These results could hardly be interpreted as indicating, even after the lapse of 192 days, any marked difference in the effect of definite quantities of chloroform upon the activity of enzymes. The germ content, as shown by bacteriological analysis, is in entire agreement with the results of chemical analysis.

From these results we see that in the presence of 2.5 per ct. of chloroform the increase of soluble nitrogen is continuous and

considerable. However, these results do not enable us to know whether the chloroform exercised any restraining influence upon the activity of the enzyme. Any such repressing effect of chloroform upon enzyme action could be directly shown only by using as a means of comparison milk containing no chloroform, but under such conditions the action of bacteria would render the comparison worthless.

A comparison of the changes produced in the bottles containing the different percentages of chloroform shows a surprisingly small decrease of change in bottles having the larger proportions of chloroform. This tends to show that chloroform restrains enzyme action only slightly.

The germ content, even in the bottles containing only 2.5 per ct. of chloroform, was so small that the observed changes were undoubtedly due to the enzymes present in the milk at the beginning of the experiment.

EFFECT OF VARYING PERCENTAGES OF FAT UPON THE ANTISEPTIC VALUE OF CHLOROFORM.

In the case of ether, Babcock and Russell[16] have shown that it has a strong tendency to combine with the fat present in such a way as not to exert its anæsthetic influence. For this reason rich cream could hardly be kept from decomposing through bacterial action when ether was used.

To test this phase of the question with chloroform, two series of bottles were prepared. The first contained 10 per ct. and the second 20 per ct. of butter-fat and in each series duplicate bottles contained 2.5, 5, 10 and 20 per ct. of chloroform.

In order that the transformations in each of the bottles in the two series should be directly comparable when expressed in percentages of total nitrogen, it was necessary that for a given quantity of nitrogen in any bottle there should also be present a corresponding amount of enzyme.

In order to maintain these relations, each bottle contained 900 cc. of a mixture made up of 540 cc. of whole milk, together with sufficient chloroform and melted butter-fat to give the

[16] Babcock and Russell. See footnote 10.

desired percentages by volume. Water was then added to bring the total up to 900 cc.

The butter-fat used, after being heated above 185° F. (85° C.) for 10 minutes to kill the enzymes present, was filtered to remove the coagulated casein and was then decanted to free from water and salt.

The chloroform assisted in emulsifying the fat and it was only in those bottles containing the smaller percentages of chloroform that difficulty was experienced in getting satisfactory samples for chemical analysis. In order to minimize this difficulty, the bottles were warmed at 99° F. (37° C.) for a few hours before sampling in order to melt the fat. During the rest of the time they were kept at 60° F. (15.5° C.).

TABLE II.—EFFECT OF VARYING AMOUNTS OF FAT UPON THE ANTISEPTIC VALUE OF CHLOROFORM.

Proportions of			In 100 lbs. total nitrogen.			
Chloroform.	Fat.	Age.	Total soluble nitrogen.	Nitrogen in albumoses and peptones.	Nitrogen in amides.	Number of germs per cc.
Per ct.	*Per ct.*	*Days.*	*Lbs.*	*Lbs.*	*Lbs.*	
		Fresh:	——	——	——	17,124
20	10	14	19.31	10.52	8.79	——
20	20	14	22.35	10.07	12.28	——
10	10	14	21.92	12.86	9.06	——
10	20	14	19.47	9.38	10.09	——
5	10	14	24.45	15.09	9.36	——
5	20	14	23.58	12.23	11.35	——
2.5	10	14	28.14	16.21	11.93	——
2.5	20	14	28.82	15.65	13.17	——
20	10	56	35.47	21.56	13.91	165
20	20	56	34.85	20.04	14.78	163
10	10	56	38.06	23.20	14.86	167
10	20	56	38.23	21.26	16.97	——
5	10	56	39.24	23.03	16.21	113
5	20	56	39.48	22.36	17.12	82
2.5	10	56	38.26	24.44	13.82	209
20	10	112	34.66	18.28	16.38	298
20	20	112	36.74	20.24	16.50	——
10	10	112	37.08	18.62	18.46	260
10	20	112	41.78	21.40	20.38	142
5	10	112	40.82	19.35	21.48	196
5	20	112	43.05	23.95	19.10	107
2.5	10	112	36.48	18.53	17.95	274
2.5	20	112	38.81	19.09	19.72	34

The preceding table does not show any marked influence due to the presence of such varying amounts of fat.

There are more bacterial spores present than are shown in the results given in Table I. This is probably due to the combined action of a number of factors: (1) The heating of the butter was not high enough to kill the spores introduced from that source; (2) the presence of many small globules of fat in the cultures makes counting difficult and tends to give too high figures; (3) this experiment was started in midsummer, when the air is better supplied with spores, than in midwinter, when the former investigation was begun.

A comparison of the percentages of change shown in Tables I and II after corresponding intervals shows the transformation to have been more rapid in the case of Table II. This is easily accounted for by the fact that here whole milk was used and the proportion of enzyme to nitrogen was greater than in the former case where the skim-milk was poorer in enzyme on account of the amount lost in the separator slime and in the cream.

COMPARISON OF EFFECT OF ETHER, CHLOROFORM AND A MIXTURE OF BOTH UPON ENZYME ACTION.

Milk was obtained from two cows, care being taken to brush and moisten the flank and udder and to steam the pail, but by mistake the fore-milk was used in the case of one cow. The milk was taken directly to the laboratory and plates made, which later showed a germ content of 2719 per cc. The fat content of the milk was 4.5 to 5 per ct. Duplicate bottles were prepared in three series containing (1) 15 per ct. of ether, (2) 3 per ct. chloroform and (3) a mixture containing 2.9 per ct. of ether and 2.1 per ct. chloroform. The bottles were kept at 99° F. (37° C.).

Table III.—Comparison of Effects of Ether, Chloroform, and Mixture of Both Upon the Activity of Enzymes.

Anæsthetic used.					In 100 pounds total nitrogen.				
		Mixture.							
Ether.	Chloroform.	Ether.	Chloroform.	Age.	Total soluble nitrogen.	Nitrogen in albumoses.	Nitrogen in peptones.	Nitrogen in amides.	Number of germs per cc.
Per ct.	*Per ct.*	*Volumes.*		*Days.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	
15	....	....		2	11.92	3.95	2.93	5.04	132
				Fresh	——	——	——	——	2719
	....	3	2	2	13.61	4.54	3.87	5.19	140
	3	....		2	13.18	5.66	2.38	5.14	93
15	....	....		5	16.75	4.81	5.64	6.30	19
	....	3	2	5	14.90	4.26	4.25	6.39	116
	3	....		5	13.23	3.70	3.60	5.93	28
15	....	....		8	20.73	6.38	5.65	8.70	——
	....	3	2	8	17.67	5.18	4.71	7.78	——
	3	....		8	17.31	4.26	4.62	8.43	——
15	....	....		14	25.64	9.90	4.72	11.02	100
	....	3	2	14	25.92	8.98	3.98	12.96	5
	3	....		14	24.82	9.16	3.61	12.04	6
15	....	....		21	32.49	14.34	4.90	13.25	121
	....	3	2	21	29.71	11.29	4.53	13.89	62
	3	....		21	27.89	10.55	4.81	12.50	6
15	....	....		28	35.81	14.89	8.42	12.50	161
	....	3	2	28	32.12	10.74	6.85	14.55	18
	3	....		28	29.80	11.66	5.64	12.50	4
15	....	....		35	36.47	15.18	7.31	13.89	——
	....	3	2	35	32.49	13.24	5.46	13.79	11
	3	....		35	30.36	12.22	6.01	12.13	5
15	....	....		42	39.63	18.98	7.87	12.78	138
	....	3	2	42	36.57	15.56	7.59	13.42	13
	3	....		42	35.36	15.74	7.61	12.00	6
15	....	....		56	45.75	19.45	11.39	14.91	183
	....	3	2	56	40.28	17.50	10.83	11.95	5
	3	....		56	Lost.				
15	....	....		84	55.01	22.22	15.38	17.41	320
	....	3	2	84	48.44	17.88	12.60	17.96	4
	3	....		84	45.83	18.52	10.83	16.58	3
15	....	....		137	60.74	15.43	24.03	21.28	113
	....	3	2	137	57.33	14.73	24.08	18.52	2
	3	....		137	Lost.				1

From these results it is seen that a slightly greater amount of soluble nitrogen was formed in the presence of 15 per ct. of ether

than under either of the other two conditions. From this it might be inferred that 15 per ct. of ether was more favorable to enzyme action than 3 per ct. chloroform, but the results of the bacteriological analyses give some reason for believing that there had taken place a growth of bacteria. There had probably been a corresponding increase in the amount of bacterial enzyme. This is rendered more likely by the fact that the bacteria in this case were almost entirely of a single kind, which showed ability to grow in the presence of ether, formed spores quickly in almost every cell and elaborated enzyme with great freedom.

This experience has made us slow to accept as trustworthy any results obtained with the use of ether, when the conditions are not constantly controlled by quantitative examination of the bacterial content.

COMPARISON OF EFFECTS OF CHLOROFORM AND FORMALIN UPON ACTIVITY OF ENZYMES.

Jensen[17] in a suggestive article on the enzymes of cheese ripening has called attention to the use of 0.1 per ct. of formalin in studying their activity. Babcock and Russell[18] have stated that comparatively small amounts of this substance completely inhibit enzyme activity. The use of even the amounts recommended by Jensen is to be looked upon with suspicion until the influence of formalin upon enzyme action is more fully investigated.

In order to facilitate comparisons at some future time, we give the results of parallel examinations of four samples of milk containing respectively 4 per ct. of chloroform and 0.1 per ct. of formalin by volume. Unfortunately the strength of formalin was not redetermined but it was the 40 per ct. article of commerce.

The milk in this case was obtained from the four quarters of a single cow at one milking. The flank and udder were brushed and moistened. The hands of the milker were smeared with vaselin and the milk was caught in four-inch glass funnels lead-

[17] Jensen. See No. 9.

[18] Babcock and Russell. Ann. Rept. Wis. Exp. Sta. 15:77 (1898).

ing into glass bottles, all of which had been carefully steamed. The milk was taken at once to the laboratory and placed under the influence of chloroform and formalin at 99° F. (37° C.).

TABLE IV.—COMPARISON OF EFFECTS OF FORMALIN AND CHLOROFORM UPON ACTIVITY OF ENZYMES.

MILK DRAWN OCT. 10.

Germicide used.			In 100 lbs. total nitrogen.			
Formalin 0.1 per ct.	Chloroform. 4 per ct.	Age.	Total soluble nitrogen.	Nitrogen in albumoses and peptones.	Nitrogen in amides.	Number of germs per cc.
		Days.	*Lbs.*	*Lbs.*	*Lbs.*	
		Fresh	——	——	——	87
I	....	14	37.50	20.47	17.03	1
	II	14	53.09	23.84	29.25	51
I	....	42	50.26	28.19	22.07	0
	II	42	64.22	24.57	39.65	38
I	....	77	59.18	35.87	23.31	1
	II	77	72.57	33.63	38.94	5
I	....	152	69.94	22.12	47.82	*
	II	152	67.62	43.58	24.04	20
		Fresh	——	——	——	6
II	....	14	21.28	12.81	8.47	0
	IV	14	35.46	21.97	13.49	9
II	....	42	23.01	13.73	9.28	6
	IV	42	36.56	21.36	15.20	4
III	....	77	24.32	16.67	7.65	0
	IV	77	42.96	27.78	15.18	1
III	....	152	24.67	17.70	6.97	1
	IV	152	43.59	31.40	12.19	2
		Fresh	——	——	——	232
V	....	14	37.42	20.98	16.44	0
	VI	14	49.83	25.63	24.20	3
V	....	42	42.89	24.96	17.93	3
	VI	42	63.58	27.36	36.22	18
V	....	77	53.50	31.95	21.55	2
	VI	77	68.50	31.12	37.38	1
V	....	152	48.70	27.96	20.74	0
	VI	152	63.89	36.10	27.79	0

* Bacteria present in large numbers.

NOTE.—I and II, front right quarter; III and IV, front left; V and VI, back right; VII and VIII, back left.

TABLE IV.—*Continued.*

Germicide used.			In 100 lbs. total nitrogen.			
Formalin 0.1 per ct.	Chloroform 4 per cent.	Age.	Total soluble nitrogen.	Nitrogen in albumoses and peptones.	Nitrogen in amides.	Number of germs per cc.
		Days.	*Lbs.*	*Lbs.*	*Lbs.*	
		Fresh	——	——	——	138
VII	....	14	32.41	19.63	12.78	3
	VIII	14	50.67	29.42	21.25	3
VII	....	42	40.12	27.47	12.65	2
	VIII	42	57.23	29.72	27.51	1
VII	....	77	47.00	29.40	17.60	0
	VIII	77	64.38	39.88	24.50	0
VII	....	152	49.91	34.37	15.54	0
	VIII	152	62.48	39.75	23.73	3

From the above results we see that the number of bacteria in all the bottles remained very low. In all cases the decomposition has gone on more slowly in the presence of formalin than with chloroform, as is clearly shown by the following tabulated summary of results.

TABLE IV A.—AVERAGE OF FOUR QUARTERS.

	Total soluble nitrogen.	
Age.	With formalin.	With chloroform.
Days.	*Per ct.*	*Per ct.*
14	32.15	47.26
42	39.07	55.39
77	46.00	62.10
152	45.62	60.63

In the article by Jensen previously referred to, he notes the same relation in the action of these two substances and he is inclined to hold the view that 0.1 per ct. formalin completely inhibits the action of galactase but allows bacterial enzymes to work. If this view is correct, we must consider that over 70 per ct. of the decomposition here produced in the presence of chloroform is caused by enzymes other than galactase.

It seems hardly possible that sufficient bacterial enzyme could have been formed in the cases of No. III to account for the changes observed in the presence of formalin. The milk in this quarter of the udder was unusually free from bacteria, having

been caught under most favorable conditions and placed under the influence of formalin within a few minutes.

CONNECTION BETWEEN BACTERIA IN THE UDDER AND ENZYMES IN THE MILK.

Previous investigators[19] have noted that there is considerable difference in the rate of change caused by enzymes in different samples of freshly drawn milk. These differences have been attributed to variations in the enzyme-forming activity of the milk glands, but we have been led to look for another explanation of these irregularities. The production of enyzmes on the part of certain classes of bacteria is well known, but the bacterial formation of enzymes in the udder, able to perform work in cheese ripening, is a possibility which has not been seriously considered.

The work of Ward[20] has called attention to the fact that in many cases the interior of the udder is inhabited by certain microörganisms which find the conditions favorable to their continued development. In working with certain Station cows we have found that in some cases large numbers of germs were present in the milk last drawn. This condition existed whenever examinations were made during a period of some months.

By comparing the germ content of the whole mess of milk, after rejecting the milk first drawn, with the germ content of the milk last drawn, or strippings, it is often found that the number present in the whole mess exceeds that in the strippings by an amount hardly larger than would be expected as a result of unavoidable contamination during milking.

This is shown in the following table which gives the number of bacteria found per cubic centimeter in the whole mess and in the strippings from each quarter of a single cow at three successive milkings. In all cases the first few streams from each quarter were rejected.

---

[19] Babcock and Russell. See No. 10.

[20] Ward. Bul. No. 178 Cornell Exp. Sta. (1900).

TABLE V.—NUMBER OF BACTERIA PER CUBIC CENTIMETER IN WHOLE-MILK AND STRIPPINGS.

DATE.	Front left quarter.		Front right quarter.		Back left quarter.		Back right quarter	
	Whole-milk.	Strippings.	Whole-milk.	Strippings.	Whole-milk.	Strippings.	Whole-milk.	Strippings.
June 11, p. m....	53	26	———	56	140	173	401	716
June 12, a. m....	646	244	216	429	442	493	629	1870
June 12, p. m....	88	22	36	305	96	105	789	975

These data strongly support the idea that the interior of the udder in such cases is seeded with these organisms, which are generally yellow cocci, capable of liquefying gelatin.

Most striking are thase cases in which the interior of certain quarters of the udder is highly contaminated with certain organisms for long periods, while, at the same time, one or more quarters of the udder in the same animal may remain comparatively free from germ life. In the case of the cow used in collecting the data shown in the above table, examinations of the strippings were made extending over four months. Samples were collected by catching one of the last streams from each quarter in a sterile test tube, except in a few cases in which they were drawn with a sterile milking tube. The samples were taken at once to the laboratory and plates prepared containing 1 cc. and 0.5 cc. of the milk. The results are shown in the following table:

TABLE V A.—NUMBER OF BACTERIA PER CUBIC CENTIMETER IN THE STRIPPINGS OF COW NO. 8.

DATE.	Front left quarter.	Front right quarter.	Back left quarter.	Back right quarter.
May 26..............................	———	22	296	372
June 11, p. m.......................	26	56	173	716
June 12, a. m.......................	244	429	493	1870
June 12, p. m.......................	22	305	105	975
July 12..............................	22	48	2106	488
July 18..............................	36	55	280	868
July 27..............................	211	10	388	628
Sept. 7..............................	391	3684	631	656
Sept. 20..............................	132	450	356	9967
Oct. 10..............................	6	87	138	232

This table shows that in general the strippings from the back right quarter had a germ content of 500 to 800 per cubic centi-

meter; the back left quarter had slightly less; the front left quarter had often less than 100 per cubic centimeter, and the front right quarter but little more.

Making allowance for the work done by galactase, the milk from different quarters of the udder of the above mentioned cow should show different rates of chemical change proportional to the number of germs present in the respective quarters of the udder, if these changes are to be associated with contamination within the udder.

The results already given in Table IV, under chloroform, relate to this point. The quarters of the udder are there designated as follows: II, front right; IV, front left; VI, back right; VIII, back left. The second determination was made in the presence of 4 per ct. of chloroform. In order to obtain sufficient material for a large number of analyses, three successive messes of milk were collected and united. Care was taken to reject the fore-milk and keep out bacteria from other sources. The following table shows the results in this test up to 15 weeks:

TABLE V B.—SOLUBLE NITROGEN FORMED IN MILK FROM DIFFERENT QUARTERS OF UDDER.

MILK DRAWN JUNE 11 AND 12.

AGE OF MILK WHEN ANALYZED.	Soluble nitrogen in 100 lbs. total nitrogen.			
	Front left quarter.	Front right quarter.	Back left quarter.	Back right quarter.
Days.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
7	27.01	29.23	48.23	46.66
21	36.25	39.75	56.61	56.66
35	36.65	40.60	59.37	57.54
49	lost	40.48	60.68	59.63
105	lost	55.31	77.29	71.63

The results given in Tables IV and VB show in a general way that there is a relation between the numbers of bacteria present in the udder and the rapidity with which the milk produced there undergoes self-digestion in the presence of chloroform or formalin.

It may be held that the presence of these bacteria has merely stimulated the production of an extra amount of galactase, but

many of these bacteria are able to bring about the liquefaction of gelatin, a fact which suggests that they have played a part in enzyme formation within the udder. However, it is impossible to assign even an approximate value to the work performed by bacteria within the udder in the production of their enzymes, until we understand the conditions which relate to the normal formation of galactase.

V. COMPARISON OF RIPENING PROCESS IN CHEESE MADE WITH CHLOROFORM AND IN NORMAL CHEESE.

Previous attempts to study the part played by enzymes in cheese ripening have proceeded indirectly by a study of enzyme action in milk or have been carried out with cheese in a fragmentary manner. In addition to the early work of Adametz, Babcock and Russell report that they have observed the changes that have taken place at the end of about a year in a cheese containing chloroform. They also added rennet to milk containing ether and determined the general changes taking place in the coagulum. Jensen[21] also reports the changes taking place in a cheese to which he had added trypsin and ether. However, so far as we can learn, no cheese has, hitherto, been prepared under conditions essentially normal except for the presence of an anæsthetic, and been kept for a long period completely under the influence of that anæsthetic, with systematic chemical and bacteriological examinations at frequent intervals.

METHOD OF MANUFACTURE AND SAMPLING.

The preparation of a chloroform cheese presents no extreme difficulties. Chloroform added directly to the milk tends to settle to the bottom but the stirring which accompanies the manufacture serves to keep it distributed without any considerable loss from evaporation. The addition of rennet at 84 to 88° F. (29 to 31° C.), cutting and heating to 98 to 100° F. (37 to 38° C.), proceed in the usual way, except that both the curdling

[21] Jensen. *Tidskr. for Fysik. og Kemi*, 2:92-114 (1897).

of the milk and the expulsion of whey take place more slowly than in normal cheese. The expulsion of the whey is especially prolonged because of the absence of acid, and the moisture content of the resulting cheese may be somewhat higher than in a first-class normal Cheddar. After the whey is drawn and the curd is fairly well drained, it is put to press with or without previous salting.

In making more than a dozen of these cheeses at different times, we have added to the milk from 2 to 5 per ct. of chloroform by volume, and we find that the percentage of chloroform by weight in the resulting cheese mass is about three times the figure given for the milk.

The cheese is kept continuously under pressure 18 to 24 hours, and is then transferred to a room with a temperature varying only one or two degrees from 60° F. (15.5° C.) and placed under a bell jar in an atmosphere of chloroform. The moisture of cheese under bell jars remains fairly uniform.

After testing a number of receivers we have settled upon bell-jars, or carefully soldered cans which are inverted over the cheese, and fit into a groove in a heavy wooden base. The base is first boiled in paraffin to fill all the pores, and melted paraffin is used as a seal in fastening the cover into the grooves, thus reducing the loss of chloroform and moisture to insignificant amounts.

At regular intervals the cover is moved and samples taken with a sterilized tryer for chemical and bacteriological analysis. The former includes a quantitative determination of the chloroform present in the cheese. To replace the small amounts lost by leakage and evaporation, measured amounts of chloroform are added to a dish within the container at the time of each examination.

DECOMPOSITION IN CHEESE UNDER CHLOROFORM COMPARED WITH THAT IN NORMAL CHEESE.

In order to get an idea of the changes brought about by the combined influence of all the enzymes present at the time a

cheese is made, 3.5 lbs. of chloroform were added to 125 lbs. of night's and morning's milk having the degree of acidity suitable for Cheddar cheese-making. One-half ounce of Hansen's liquid rennet was added at 88° F. (31° C.), and the cheese made as described above. One-half of the resulting curd, without salting, was pressed into form of a Young America cheese. On the third day it was found to contain 35 per ct. of water and 15 per ct. of chloroform.

As a basis for comparison there is also given the analysis of a normal cheese ripened at the same temperature and having originally about the same percentage of moisture. However, since under normal conditions the moisture in a cheese rapidly decreases, while in the chloroform cheese this factor remains practically constant, there is also given the analysis of a cheese normal in every way except that it was coated with a layer of paraffin to lessen the loss of moisture.

TABLE VI.—COMPARISON OF NORMAL CHEESES, CURED WITH AND WITHOUT PARAFFIN COVERING, WITH A CHEESE MADE AND CURED WITH CHLOROFORM.

	Total water-soluble nitrogen formed for 100 lbs. nitrogen in cheese.					
CONDITIONS OF CURING.	2 weeks.	1 month.	2 months.	6 months.	12 months.	15 months.
Cheese No. 31A, cured under normal conditions..	11.50	18.50	25.10	33.70	37.30	38.66
Cheese No. 31B, covered with paraffin	12.50	19.30	25.40	37.80	40.90	44.14
Cheese No. 30A, made and cured with chloroform	5.30	5.70	8 20	14.50	22.60	27.70

In Tables VI, VII, VIII and IX, the figures given for total water-soluble nitrogen represent the amount rendered soluble after the cheese was taken from the press. Samples of the green cheese fresh from the press were analyzed, and it was found that the amount of soluble nitrogen varied considerably in different cheeses. Therefore, for the sake of more accurate comparison, the amounts of water-soluble nitrogen found in the

green cheese have been deducted and so are not included in the figures presented in these tables.

The data in Table VI show that at the end of one month the water-soluble nitrogen in the normal cheese was more than three times that contained in the chloroform cheese; gradually the difference decreased until at the end of 15 months the total decomposition in the case of the chloroform cheese amounted to 27.7 per ct. of the total nitrogen, while in a normal cheese of the same age the amount was 38.66 per ct. The enzymes present in this cheese were therefore able under favorable circumstances to accomplish about 72 per ct. as much decomposition of casein as occurred in a normal cheese. That they accomplish this fraction of the work under ordinary conditions does not necessarily follow. These results show merely that the peculiar conditions of manufacture in the presence of chloroform were not such as to prevent the enzymes from rendering cheese-casein soluble.

INFLUENCE OF SMALL AMOUNTS OF ACID ON ENZYME ACTION.

In the ordinary process of manufacture there is a gradual formation of acid within the mass through the action of becteria. In the preceding experiment acid was necessarily absent. To remedy this, another cheese was made like the preceding, except that lactic acid was added.

As before, 3.5 lbs. of chloroform were added to 125 lbs. of night's and morning's milk, sufficiently acid for cheese-making. This was curdled by one-quarter ounce of Hansen's liquid rennet added at 86° F. (30° C.). After cutting the curd and applying heat, pure lactic acid was added in small quantities at a time until the whole amounted to nearly .2 per ct. of the milk used. One-half of the resulting curd, unsalted, was pressed into a Young America cheese which, fresh from the press, contained 32 per ct. of water and 15 per ct. of chloroform.

The results of the examinations are shown below:

TABLE VII.—COMPARISON OF CHLOROFORM CHEESES MADE WITH AND WITHOUT LACTIC ACID.

Conditions of Making and Curing.	Total water-soluble nitrogen formed for 100 lbs. nitrogen in cheese.					
	1 month.	2 months.	3 months.	6 months.	9 months.	12 months.
Cheese No. 30A, made and cured with chloroform.	5.70	8.20	11.60	14.50	19.50	22.60
Cheese No. 32A, made and cured with chloroform and lactic acid.	5.70	9.40	14.00	20.60	23.20	31.65

It will be seen that in cheese 32A the amount of soluble nitrogen is greater than in 30A after the first month and continues to become greater up to the end of 12 months, the age of 32A at its last analysis. This more rapid ripening in 32A took place in spite of the fact that only one-half as much rennet was used in 32A as in 30A. Acid appears to favor enzyme action.

INFLUENCE OF SALT UPON ENZYME ACTION.

In the two preceding experiments it has been noted that one-half the curd was pressed without salting and the results previously given represent the changes taking place in unsalted cheese. However in the manufacture of Cheddar cheese, salt is never omitted and, in order to make the comparison between the chloroform cheese and normal cheese complete, the addition of salt is required.

In each of the two experiments, one-half of the curd was salted just before putting to press, the first receiving 2 ounces and the second 2½ ounces. In each case the percentage of chloroform and water was essentially the same as in the corresponding unsalted portion. The results of analysis are shown in the following table. To facilitate comparison, the results from the unsalted portions are also repeated.

Table VIII.—Comparison of Cheeses Made and Cured with Chloroform, Salted and Unsalted.

Conditions of Curing.	Total water-soluble nitrogen formed for 100 lbs. nitrogen in cheese. 1 mo.	2 mos.	3 mos.	6 mos.	9 mos.	12 mos.	15 mos.
(1) Without lactic acid:							
Cheese No. 30A, made and cured with chloroform—not salted......	5.70	8.20	11.60	14.50	19.50	22.60	27.70
Cheese No. 30B, same as 30A, but salted.....	2.25	3.20	5.50	7.80	11.60	17.20	24.00
(2) With lactic acid:							
Cheese No. 32A, made and cured with chloroform and lactic acid—not salted............	5.70	9.40	14.00	20.60	23.20	31.65	
Cheese No. 32B, same as 32A, but salted....	3.00	4.90	6.70	9.75	12.45	19.65	

From the results here given it is seen that salt in the proportion usually present in cheese exerts a strong repressing influence upon the activity of the enzymes present. On comparing this effect of salt in the case of the cheese containing added acid with the cheese in which acid was omitted, it is seen that acid favored enzyme action here also as well as in unsalted cheese.

The results of our work up to this time appear to show, (1) that the use of chloroform excludes bacterial action in milk and cheese and limits the work of ripening to those enzymes contained in milk when made into cheese; (2) that the presence of salt noticeably decreases the effect of such enzymes; (3) that the presence of two-tenths of one per ct. of lactic acid increases the ripening action, at least of rennet enzymes; (4) that the percentage of cheese-casein made soluble by the enzymes under consideration in nine months (which may be regarded as the extreme limit of the commercial life of Cheddar cheese, kept under usual conditions) is about 12 per ct., or one-third the amount of soluble nitrogen found in normal cheese; and (5) that the amount of ripening caused by enzymes present in the milk when made into cheese is apparently more limited than was previously supposed.

We may say that the limited part apparently taken by such enzymes in ripening cheese is a result we did not anticipate when

undertaking the work. We have additional experimental work under way for the purpose of testing these results more rigidly.

DIFFERENCE IN CHARACTER OF CHEMICAL CHANGES IN NORMAL AND IN CHLOROFORM CHEESE.

An examination of the detailed data secured with normal and with chloroform cheese shows clearly a marked difference in the character of the changes taking place in the soluble nitrogen-compounds. This difference is seen if we study the amounts of albumoses and peptones in relation to amides, and also the relative amounts of ammonia found.

The following tabulated comparison in case of cheese 34C and 34B, which were made with and without chloroform from different portions of the same milk, illustrate the points in question.

TABLE IX.—SHOWING DIFFERENCE IN CHARACTER OF CHEMICAL CHANGES IN NORMAL AND IN CHLOROFORM CHEESE.

CHARACTER OF CHEESE.	Age.	N. in albumoses and peptones.	N. in amides.	Ratio o (1) to (2).	fN. in ammonia.
	Months.	(1)	(2)		
Cheese 34C—normal............	1	2.95	5.42	1:1.80	.86
Cheese 34B—chloroform........	1	3.71	0.86	1:0.23	0
Normal cheese	1½	2.51	8.49	1:3.40	1.29
Chloroform cheese	1½	7.31	1.82	1:0.25	0
Normal cheese	3½	5.37	12.60	1:2.40	2.51
Chloroform cheese	3½	10.20	3.22	1:0.31	0
Normal cheese	5½	4.97	18.50	1:3.70	3.38
Chloroform cheese	5½	12.40	4.73	1:0.39	0
Normal cheese	7	3.08	20.10	1:6.50	4.42
Chloroform cheese	7	10.90	8.11	1:0.74	0
Normal cheese	9	2.70	23.50	1:8.70	4.87
Chloroform cheese	9	12.52	11.60	1:0.93	0

Stated in a general way, these results show (1) that, in cheese made and cured with chloroform, the amount of albumoses and peptones is largely in excess of the amount of amides; (2) that the reverse is true in normal cheese; and (3) that ammonia appears in normal cheese much earlier and in larger quantities than in chloroform cheese.

Making a detailed comparison, we note the following points:

(1) In the normal cheese at the age of one month, the amount of amides was 1.8 lbs. for each pound of albumoses and peptones. This ratio increased until at nine months it was 8.7, nearly five times as great as at the end of one month.

(2) In the chloroform cheese, the amount of amides was not quite one-fourth of the amount of albumoses and peptones at the age of one month. The relative amount slowly increased, until at the end of nine months the amount of amides was nearly equal to that of albumoses and peptones.

(3) In chloroform cheese, no ammonia had appeared at the end of nine months; in the normal cheese, nearly one per ct. of the total nitrogen was present as ammonia at the end of one month and this amount steadily increased.

From these results it is seen that, in a normal cheese, the amides steadily increase, while the albumoses and peptones increase for some months and then decrease. In a chloroform cheese, the different classes of compounds under discussion all increase continuously from the beginning for many months.

In normal cheese, traces of ammonia appear at an early stage of ripening, while, in chloroform cheese, the first traces usually appear only after the lapse of six months or more, and the increase is very slow, so that even after a year only minute amounts are present.

For these data it appears that there is some agent at work in normal cheese which is not active in cheese made with chloroform. Just what this additional factor is our present data do not explain, but our efforts are being directed to the task of identifying this agent.

CONDITIONS AFFECTING WEIGHT LOST BY CHEESE IN CURING.*

L. L. VAN SLYKE.

SUMMARY.

I. The loss of weight by cheese in curing has not received systematic study in America under carefully controlled conditions.

II. Equipment for investigation.—Six curing-rooms have been so built and equipped as to keep temperature and moisture under control. Each room is kept at a fixed temperature, and the different degrees represented in the work are the following: 55°, 60°, 65°, 70°, 75°, 80° F. The temperature varies only one or two degrees from the desired point, and then only for brief periods. The moisture is kept mostly between 70 and 80 per ct. of saturation. The method is given for determining proportion of moisture in air, with necessary tables.

III. Conditions affecting loss of weight in cheese-curing.—The weight lost by cheese in curing is due almost entirely to evaporation of moisture from cheese, except at temperatures above 70° F., when there may be some added loss due to leakage of fat. The rapidity and extent of loss per 100 pounds of cheese vary with the following conditions: (1) The percentage of moisture originally present in the cheese. The more moist the cheese, the greater and more rapid is the loss of weight. (2) The texture of cheese. The more open the texture, the greater the loss of moisture. (3) Temperature. Loss of weight increases with increase of temperature. (4) Size and shape of cheese.

*A reprint of Bulletin No. 207.

Loss of weight increases, when the size of cheese decreases. Increase of height or diameter of cheese decreases loss of weight. (5) Proportion of water-vapor in air. The greater the moisture in the air of the curing-room, the smaller is the loss of weight of cheese.

IV. Some practical applications.—(1) Value of water in cheese to dairymen. Water, put in cheese in right proportions and kept there, is money to the dairyman, increasing amount of cheese to be sold. (2) Moisture in cheese in relation to quality. Excessive loss of moisture in curing seriously injures commercial quality of cheese. (3) What percentage of moisture should cheese have? When consumed, cheese should have not less than 33 per ct. moisture. If cured at low temperatures, larger amounts can be held to advantage of quality. (4) Value of water in cheese to consumers. Cheese with fairly large amount of moisture, cured at proper temperature, is more palatable to most consumers. Less rind is thrown away. (5) Variation of loss of moisture with size of cheese. As small cheese loses moisture more rapidly than larger cheese, greater pains must be taken with small cheese to prevent excessive loss of moisture. (6) Loss of moisture and loss of fat. To avoid loss of fat by leakage and excessive loss of moisture, cheese should not be kept above 70° F. for any length of time.

V. Prevention of loss of moisture in curing cheese.—Three systems have been proposed: (1) Immediate sale and removal of newly-made cheese. In this case the buyer assumes responsibility of curing in cold-storage and secures all the benefits. (2) Central curing-rooms, located so as to care for product of several factories and equipped with complete facilities for controlling temperature and moisture. This system has greater promise than any other. (3) Special curing-rooms in each factory are desirable when central curing-rooms cannot be had. Details are given, taken mainly from Bulletin No. 70 of the Wisconsin Agricultural Experiment Station, describing construction of curing-rooms and various kinds of sub-earth ducts.

I. INTRODUCTION.

It is well known among cheesemakers that cheese begins to lose weight immediately from the time it is taken from the press and placed upon the shelves of the curing-room; this loss continues indefinitely. While there has been some study in Europe relating to the conditions and extent of loss of weight in cheese-curing, the results thus obtained are not generally applicable to the conditions prevailing in this country. Some study of this question has been made in America, but it has been rather desultory in character, lacking in systematic plan and thoroughness, and under circumstances not permitting careful control of conditions.

II. EQUIPMENT FOR INVESTIGATION.

CURING-ROOMS.

For the past three years at this Station we have been making a systematic study of the various conditions that affect loss of weight in cheese during the progress of curing. The special equipment in the way of cheese-curing rooms has given us unusual opportunities to carry on such study under well controlled conditions. We have a block of six distinct curing-rooms, separated from the outer walls of the building by a passage four feet wide. The rooms are farther insulated by double walls and air spaces on every side of each room. These rooms are 9 by 10 feet and about 8 feet high, and the wall space on three sides is provided with shelves 12 inches apart.

CONTROL OF TEMPERATURE.

The temperature and moisture in each room can be controlled independently of the other rooms. It is possible to obtain a range of temperature varying from 40 to 90 degrees Fahrenheit in every room. Each room is provided with a hot-air flue from below and a cold-air flue above, leading from the chamber in the attic, which contains ammonia expansion coils and brine tanks. These two flues, one for cold and one for hot air, are closed by

dampers, and these dampers are operated by means of compressed air tubes controlled by metallic thermostats. There is also a ventilating flue in the ceiling of each room. The thermostat is fixed so as to register some definite temperature in each room. For example, in one room the thermostat is set at 70° F. When the temperature falls one degree below 70° F., the thermostat is affected in such a manner that a valve is turned and this causes compressed air to close the cold-air damper in the ceiling and to open the hot-air damper in the floor, thus restoring the temperature to 70° F. On the other hand, when the temperature rises to 71° F., the cold-air flue in the ceiling is opened and the hot-air flue is closed, when the temperature soon begins to drop. Thus we have an alternate admission and exclusion of hot air and cold air, causing the temperature to rise a little above or fall slightly below the given point at which it is desired to hold the temperature of the room. So delicate is the operation of this system that merely breathing upon the thermostat will open the cold-air flue, while fanning the thermostat will open the hot-air damper. We are able, therefore, by this system to hold temperature within a very limited range. Under most favorable conditions, the limit of variation is only two degrees. Even with a much wider temporary variation the temperature of the interior of a cheese would not be affected to the extent of more than a small fraction of a degree, as we have shown by placing a thermometer inside a cheese and keeping it there under observation for several weeks.

CONTROL OF MOISTURE.

It is more difficult to control moisture than temperature, so as to hold it within narrow limits. The most practicable and efficient method we have found adapted to our conditions is to make use of yard-wide pieces of coarse felt, having a strong capillary power. One end of the felt dips in a trough of water situated near the top of the room and the lower end drops into a trough placed on the floor. The water is sucked in by the felt at the upper end and gradually distributes itself throughout

the whole piece, the excess of water dripping into the lower trough. It is necessary occasionally to boil these pieces of felt cloth in water slightly acidulated with some acid, like acetic or hydrochloric, in order to remove mineral salts that accumulate and interfere with capillary action. The use of distilled or rain water would obviate this difficulty. Thus far we have kept the moisture as nearly as possible at 75 per ct. of saturation, though variations of 5 per ct. below and 10 per ct. above may occur at times. The natural tendency is toward a higher percentage of relative moisture at lower temperatures.

METHOD OF DETERMINING MOISTURE IN AIR.

The relative amount of moisture in air can be determined by means of an instrument known as a *hygrometer*, of which there are several forms. One form indicates the percentage of moisture directly by means of a needle or hand; this is the most convenient kind of hygrometer, and is probably sufficiently accurate for ordinary purposes. A more accurate instrument consists of two sensitive, standard thermometers. The bulb of one is exposed to the air directly, like any thermometer, and is known as the dry-bulb or dry thermometer, while the other has its bulb wrapped in a piece of muslin to hold water, and is known as the wet-bulb or wet thermometer. The wet thermometer should be fixed in a frame that enables one to whirl it easily. The form of hygrometer used by us is made by Julian P. Friez, Baltimore, Md. The dry thermometer indicates the temperature of the air in the room. The wet thermometer, properly used, indicates a lower temperature than does the dry thermometer, because the water in the muslin bound about the bulb evaporates and the evaporation is accompanied by a lowering of the temperature immediately around the bulb. The less moisture there is in the air, the more rapidly does evaporation take place and the lower is the temperature indicated by the wet thermometer. The greater the moisture in the air, the less rapid is the evaporation and the smaller the difference between

the temperature indicated by the dry and wet thermometers. When the two thermometers indicate the same temperature, then there is no evaporation taking place from the bulb of the wet thermometer, because the air is saturated with moisture, that is, holds as water-vapor all it can at that temperature. If the moisture is increased beyond this point or if the temperature is lowered, some of the water-vapor will be condensed into visible drops of water.

In order to use a hygrometer for the purpose of ascertaining the proportion of moisture in air, we note first the temperature indicated by the dry thermometer. Then we dip in water the bulb (wrapped in muslin) of the wet thermometer, whirl it vigorously for one or two minutes, and then quickly read the temperature. The whirling is for the purpose of quickly causing evaporation. It is well to repeat the whirling two or three times, noting the temperature of the wet thermometer after each whirling. The different temperature readings should agree if the whirling operation is equally thorough each time. Pains must be taken to keep the muslin about the bulb moist during the different whirlings. After getting the temperatures of the two thermometers, we subtract the number indicating the temperature of the wet thermometer from the number showing the temperature of the dry thermometer. Then we turn to prepared tables of figures and find the column of figures, at the top of which is the difference obtained by the foregoing subtraction. If the exact figure is not there we take the one nearest it. We then follow down this column until the figure is found opposite the number in the left hand column which is the same as the temperature indicated by the dry thermometer. The number thus found indicates the relative amount of moisture in the air, or percentage of saturation; that is, how much moisture the air actually holds compared with what it could hold at that temperature if saturated.

The preceding statements can be better understood by use of a specific illustration. Suppose we find by actual trial that the

readings of the two thermometers of our hygrometer are as follows:

Dry thermometer	70° F.
Wet thermometer	65° F.
Difference	5° F.

We turn to the tables given at the end of this bulletin (taken from Weather Bulletin No. 127, U. S. Dept. Agr.) and look in the upper horizontal row for the number 5. Having found this, we follow down the column until we come opposite the number indicated by the dry thermometer (70) in the vertical column at the extreme left. This brings us to the figure 77, which indicates the relative amount of moisture in the air; in other words, the air contains 77 per ct. as much moisture as it can hold at 70° F.

III. CONDITIONS AFFECTING LOSS OF WEIGHT IN CHEESE-CURING.

The loss of weight in cheese during the process of curing under proper conditions may be regarded for practical purposes as being due entirely to the evaporation of water from the cheese. Of course, the mechanical loss of fat by exudation from cheese kept at high temperatures must be considered, but with proper control of temperature such loss will not take place. The small amount of loss due to the formation and escape of carbon dioxide and other gases from cheese can be neglected for the purpose we now have in view.

The rapidity and extent of loss of moisture in cheese during the process of curing vary with several conditions, chief of which are the following:

(1) The percentage of moisture originally present in the cheese.

(2) The texture of the cheese.

(3) The temperature of the curing-room.

(4) The size and shape of the cheese.

(5) The proportion of water-vapor present in the air of the curing-room.

LOSS OF MOISTURE AS INFLUENCED BY THE PERCENTAGE OF WATER PRESENT IN GREEN CHEESE.

In presenting the results of our study under this division of our subject, we will first make use of some extreme cases, in which the percentage of water in the cheese varied from 55 to 35. In the following table we give the percentage of water originally present in the cheese fresh from press and the amount of water lost per 100 pounds of cheese for each of four weeks, the conditions of temperature and moisture of air being the same for the different cheeses.

TABLE I.—LOSS OF MOISTURE IN CHEESES CONTAINING DIFFERENT PERCENTAGES OF WATER.

WATER IN 100 LBS. GREEN CHEESE.	Water lost by 100 lbs. of green cheese.			
	In 1 week.	In 2 weeks.	In 3 weeks.	In 4 weeks.
Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
55	9.0	11.2	12.3	16.8
50	5.5	9.2	11.0	12.9
45	4.5	6.3	8.0	9.5
35	3.3	4.2	4.9	5.7

An examination of these figures suggests the following statements:

(1) There is a marked general tendency for very moist cheese to lose water more rapidly than cheese having less moisture, other conditions being uniform. Thus, the cheese containing 55 per ct. of moisture lost nearly three times as much moisture by evaporation each week as did the cheese containing 35 per ct. of water, and nearly twice as much as the cheese containing 45 per ct. of moisture.

(2) At the end of four weeks, the cheese containing 55 per ct. of moisture had lost about one-third of its water; the one with 50 per ct. had lost one-fourth; the one containing 45 per ct., one-fifth; and the one with 35 per ct., one-sixth. It is thus seen that the more moist the cheese the greater is the proportion of its water lost by evaporation; and, hence, the moisture in the different cheeses tends to become more nearly alike. However, they would not all reach the same condition of moisture-content, except under very unusual conditions.

The results presented in such extreme cases are full of interest, but do not have practical application to conditions commonly present in cheese making. There is, however, a practical question in this connection to be considered later.

We will consider one more illustration, in which the variations of moisture in the green cheeses are within narrow limits and essentially similar to cases occurring in factory work. The data in the following figures represent averages obtained with four different lots of cheese. The cheeses weighed about 30 lbs. each.

Water in 100 lbs. green cheese, lbs.	41.7	38.7	37.6	35.4
Water lost by 100 lbs. cheese in 6 weeks, lbs.	5.3	4.6	4.5	4.2

These data show that the loss of moisture increases as the amount of water in the green cheese increases, even though the amount of moisture in the green cheese varies within comparatively narrow limits. Variation in other conditions may, of course, interfere with this general tendency.

LOSS OF MOISTURE AS INFLUENCED BY TEXTURE OF CHEESE.

Cheese filled with holes will occupy more volume than the same weight of cheese free from holes. Hence, cheese with such faulty texture has a larger surface exposed for evaporation relative to its weight and will lose more moisture. Then, in addition, the presence of numerous holes in cheese greatly facilitates the escape of moisture from the interior of the cheese to the surface. This is a partial explanation of the fact that cheese high in moisture loses water more rapidly than cheese containing less moisture. It is well known that cheese containing high percentages of water usually develops holes abundantly, especially when cured at or above ordinary temperatures.

LOSS OF MOISTURE AS INFLUENCED BY TEMPERATURE.

In our study of the influence of temperature upon loss of moisture we used six different temperatures, viz.: 55°, 60°, 65°,

70°, 75°, 80° F. In one case a temperature of about 32° F. was employed. The degree of moisture was kept as nearly uniform as possible in the different curing-rooms.

In this connection we will present the results secured with cheeses 15 inches in diameter, and weighing, fresh from press, about 65 lbs., the usual standard size of the most common type of American Cheddar cheese. Work with the cheeses at 75° and 80° F. was discontinued after 16 weeks. The number of cheeses of this size available for our work has not been sufficient to cover the ground as fully as is desirable.

TABLE II.—LOSS OF MOISTURE AT DIFFERENT TEMPERATURES.

TEMP. OF CURING-ROOM.	Water lost by 100 lbs. of green cheese in									
	1 week.	2 weeks.	3 weeks.	4 weeks.	8 weeks.	12 weeks.	16 weeks.	20 weeks.	24 weeks.	28 weeks.
Deg. F.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
55	1.6	2.6	3.2	3.7	5.2	6.1	6.8	7.5	8.1	8.6
60	1.7	2.8	3.4	3.9	5.5	6.5	7.5	8.5	9.3	9.9
65	1.9	3.0	3.6	4.1	5.8	7.0	8.2	9.2	10.1	10.5
70	2.0	3.1	3.7	4.3	6.0	7.8	9.0	10.1	11.1	12.0
75	2.2	3.3	4.0	4.7	7.2	9.7	11.4	——	——	——
80	2.4	3.7	4.5	5.2	8.3	11.6	15.5	——	——	——

Attention is called to the following points:

(1) At 55° F. the total loss of moisture is less than it is at the higher temperatures. This is true at the end of the first week and continues so through all the weeks following.

(2) The loss of weight increases in a marked degree with increase of temperature. During the first four weeks the loss of weight increased about three ounces for each increase of five degrees of temperature between the limits of 55° and 70° F. From 70° to 75° F., the increase was six and one-half ounces, and from 75° to 80° F., the increase was eight ounces for each 5° F. additional. As between 55° and 80° F. the loss increased on an average one ounce per 100 lbs. of cheese for each additional degree Fahr. At the end of two months, comparing 55° and 80° F. the loss increased two ounces per 100 lbs. of cheese for each degree; and at the end of three months, three and one-half ounces.

(3) The average weekly loss of weight or rate of loss increases with increase of temperature. This statement can be more clearly understood by means of the subjoined table, which has been prepared from the data given in Table II.

TABLE III.—AVERAGE WEEKLY LOSS AT DIFFERENT TEMPERATURES.

TEMP. OF CURING-ROOM.	Average loss per week. Water lost by 100 lbs. of green cheese.									Lbs. total loss for six months.
	1st week.	2d week.	3d week.	4th week.	2d month.	3d month.	4th month.	5th month.	6th month.	
Deg F.	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Lbs.*
55	25.6	16.0	9.6	8.0	6.0	3.6	2.8	2.8	2.4	8.1
60	27.2	17.6	9.6	8.0	6.4	4.0	4.0	4.0	3.2	9.3
65	30.4	17.6	9.6	8.0	6.8	4.8	4.8	4.0	3.6	10.1
70	32.0	17.6	9.6	9.6	6.8	4.8	4.8	4.4	4.0	11.1
75	35.2	17.6	10.2	10.2	10.0	10.0	6.8	——	——	——
80	38.4	20.8	12.8	10.2	12.4	13.2	15.6	——	——	——

An examination of this table shows the smallest weekly loss at 55° F. in every case and a clear tendency for the loss to increase with increase of temperature.

(4) It is noticeable that the loss is greater the first week than during any other week. At 55° and 60° F. the loss the first week is equal to the combined losses of the second and third weeks. At the higher temperatures the loss during the first week is nearly equal to the combined losses of the second, third and fourth weeks.

(5) The weekly loss decreases continuously as the cheese grows older. This is true at all temperatures.

(6) The comparatively rapid loss of moisture during the early stage of curing is entirely consistent with the fact previously shown, that loss of moisture increases with the moisture content of the cheese. The cheese contains its maximum of moisture when new. In addition, the bandage holds considerable water which quickly evaporates. Then, again, the outer surface of the cheese, in drying, begins to harden, the pores of the cheese-cloth filling to some extent with dried matter, and this condition tends constantly more and more to diminish evaporation, provided cracking is prevented.

(7) An examination of Table III shows that the cheese at 80° F., after the fourth week had an increased weekly loss of

weight, while at the lower temperatures the weekly loss fell gradually. This extra loss was due to leakage of fat from the cheese, which was very noticeable on the surface of the cheese and on the shelf. The cheese at 75° F. also lost some fat by leakage, as the figures in the table indicate for the second and third months.

(8) To illustrate the influence of temperature below 55° F. upon loss of moisture in cheese curing, we give some results secured with cheeses weighing 30 pounds, 13 inches in diameter. The last weighing was taken when the cheeses were five weeks old.

Temperature, degrees F.	32	55	60	70
Weight, loss by 100 lbs. of cheese in five weeks, lbs.,	3.0	4.6	4.6	4.9

The reduction in temperature below 55° F. is seen to be attended with decreased loss of moisture in a marked degree.

LOSS OF MOISTURE AS INFLUENCED BY SIZE AND SHAPE OF CHEESE.

We will first present data secured with cheeses having the same diameter but varying in height. These cheeses were 7 inches in diameter, being of the type commonly known as "Young Americas." They were made from one vat of milk and subjected to uniform conditions. They were all kept at a uniform temperature of 65° F.

TABLE IV.—WEIGHT LOST BY CHEESE OF VARYING HEIGHT AND UNIFORM DIAMETER.

HEIGHT OF CHEESE.	Weight of green cheese.	Water lost by 100 lbs. of green cheese in								
		1 week.	2 weeks.	3 weeks.	4 weeks.	8 weeks.	12 weeks.	16 weeks.	20 weeks.	24 weeks.
Inches.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
3	4.6	3.4	5.3	6.4	7.0	10.7	12.9	13.9	15.9	17.0
4	6.1	3.3	5.1	6.1	6.7	9.7	11.5	13.0	14.0	15.6
5	7.9	2.8	4.2	5.5	6.3	8.3	9.8	11.2	12.6	13.4
6	9.3	2.5	3.9	5.2	6.0	7.8	9.4	10.6	11.6	12.8
7	11.0	2.3	3.4	4.7	5.6	7.4	8.9	10.5	11.2	12.4

The data in this table suggests the following statements:

(1) The loss of weight was greatest in the cheese whose height was least. The loss decreased with increase of height. Taking

the total loss for the first four weeks, it is seen that an increase of one inch in height reduced the loss of moisture about 5½ ounces per 100 pounds of cheese.

(2) The general tendency in all the cheeses was a decrease in the weekly rate of loss of weight as the cheese grew older. The weekly rate of loss was greater in the smaller cheeses for the first two months, after which the rate was fairly uniform in all the cheeses.

We will now consider data furnished by cheeses having approximately the same height but varying in diameter. The results represent, in case of the smaller cheeses, averages covering from ten to twenty-five separate lots of cheese.

TABLE V.—WEIGHT LOST BY CHEESE OF VARYING DIAMETER AND UNIFORM HEIGHT.

Diameter of cheese.	Weight of green cheese.	Temperature of curing rooms.	Water lost by 100 lbs. of cheese. 1 week.	2 weeks.	4 weeks.	8 weeks.	12 weeks.	16 weeks.	20 weeks.	24 weeks.
Inches.	*Lbs.*	*Deg. F.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
15	65	80	2.4	3.7	5.2	8.3	11.6	15.5	——	——
7	9	80	3.6	5.2	7.3	10.9	12.7	14.5	16.3	17.1
15	65	75	2.2	3.3	4.7	7.2	9.7	11.4	——	——
7	9	75	3.1	4.8	6.6	9.2	11.1	12.7	14.1	15.1
15	65	70	2.0	3.1	4.3	6.0	7.8	9.0	10.1	11.1
11	23	70	3.0	4.2	6.1	7.7	9.2	10.6	11.6	12.4
7	9	70	2.9	4.5	6.2	8.9	10.9	12.2	13.9	14.6
15	65	65	1.9	3.0	4.1	5.8	7.0	8.2	9.2	10.1
13	21	65	2.0	3.4	5.1	6.2	7.7	8.7	9.3	10.2
11	22	65	2.6	3.7	5.3	6.9	8.1	9.5	10.4	11.3
7	9	65	2.5	3.9	5.6	7.9	9.5	10.9	12.1	13.1
15	65	60	1.7	2.8	3.9	5.5	6.5	7.5	8.5	9.3
13	31	60	1.7	2.7	4.3	6.1	7.3	8.4	9.5	——
11	22	60	1.9	3.6	4.5	6.3	7.5	8.7	9.6	10.5
7	9	60	2.4	3.7	5.5	7.7	9.3	10.6	11.9	12.8
15	65	55	1.6	2.6	3.7	5.2	6.1	6.8	7.5	8.1
13	29	55	1.5	2.7	4.2	5.7	7.2	7.9	8.9	9.4
11	20	55	2.1	3.6	4.6	6.4	7.4	8.8	9.4	10.1
7	9	55	2.2	3.6	5.1	7.2	8.8	9.8	11.0	12.0

A study of the preceding table brings out the following points:

(1) In general, at all temperatures, the loss of weight in cheese

increases when the diameter of the cheese decreases. Taking the cheeses having diameters of 15 and 7 inches respectively, at the age of four weeks, we see that at a temperature of 80° F. the smaller cheese has lost 2.1 pounds more per hundred pounds of cheese than has the larger cheese.

(2) The difference in loss of weight between cheeses of different diameters is greatest at 80° F. and gradually decreases with decrease of temperature. Illustrating this point with the 15 and 7 inch cheeses at the age of four weeks, we have the small cheese losing more than the large cheese by the following amounts per hundred cheese: at 80° F., 2.1 lbs.; at 75° F., 1.9 lbs.; at 70° F., 1.9 lbs.; at 65° F., 1.5 lbs.; at 60° F., 1.6 lbs.; at 55° F., 1.4 lbs.

(3) At 65° F. we find that an increase of two inches in diameter reduces the loss of weight about one-half pound per hundred pounds of cheese, when the cheeses are four weeks old. When the cheeses are 16 weeks old, the decrease in loss of weight is one pound for an increase of two inches in diameter.

We have two additional illustrations to present, in which cheeses were made from the same milk and cured under the same conditions. We present these data in the following table:

TABLE VI.—WEIGHT LOST BY CHEESES OF DIFFERENT DIAMETERS.

Diameter of cheeses.	Weight of green cheese.	Temperature of curing-room.	Water lost by 100 lbs. of cheese in							
			2 weeks.	3 weeks.	5 weeks.	7 weeks.	8 weeks.	12 weeks.	16 weeks.	20 weeks.
Inches.	*Lbs.*	*Deg. F.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
13	36	55	2.9	3.6	4.5	4.9	5.4	6.4	7.2	8.1
7	10	55	3.9	4.9	6.3	6.9	7.2	8.7	9.9	11.5
13	29	60	2.8	3.7	4.7	5.7	6.0	7.3	8.2	9.3
7	9	60	3.8	4.8	6.7	7.9	8.2	9.7	11.2	12.5

LOSS OF MOISTURE AS INFLUENCED BY PROPORTION OF WATER-VAPOR PRESENT IN AIR OF CURING-ROOM.

The relative amount of moisture in air, or, more properly, the degree of saturation, exercises a marked influence upon loss of water in cheese-ripening. While we have not carried systematic investigation far in this line, we can present data that will

clearly illustrate the influence of this factor. Cheeses, which were made from the same milk, were placed in the curing-room at 60° F. One cheese was kept on the shelf in the ordinary manner, the air of the room containing from 75 to 80 per ct. of all the moisture it could hold at 60° F. The other cheese was placed under a bell-jar and kept in an atmosphere completely saturated with moisture. The results secured by this treatment are presented in the following table. The amount of moisture in the fresh cheese was not determined and we start, therefore, with the moisture in the cheese at two weeks.

TABLE VII.—LOSS OF MOISTURE IN CHEESE KEPT IN AIR COMPLETELY AND PARTIALLY SATURATED WITH MOISTURE.

AGE OF CHEESE.	In air partially saturated.		In air completely saturated with moisture.	
	Moisture in cheese.	Water lost by 100 lbs. of cheese.	Moisture in cheese.	Water gained by 100 lbs. of cheese.
	Per ct.	*Lbs.*	*Per ct.*	*Lbs.*
2 weeks	35.99	——	35.93	——
1 month	35.23	0.76	35.87	——
2 months ...	34.86	1.13	36.01	0.08
6 months ...	31.87	4.12	37.04	0.11
12 months ...	26.30	9.69	37.63	1.70
15 months ...	24.85	11.14	37.85	1.92

Attention is called to the following points in connection with this table:

(1) In case of the cheese kept in air partially saturated with moisture, there is a loss of moisture from the first, which at the end of 15 months has reached the total of 11.14 lbs. per hundred pounds of cheese.

(2) In the cheese kept in a moisture-saturated atmosphere, there was practically no loss of moisture in the cheese, but at the end of 2 months the moisture in the cheese had actually increased and continued to increase steadily, until, at the end of 15 months, there had been an actual gain of 1.92 lbs. of moisture per 100 lbs. of cheese.

(3) The two cheeses containing the same amount of moisture at the beginning were found to differ, at the end of 15 months, 13 per ct. in moisture, as the result of being kept in air containing different degrees of moisture.

IV. SOME PRACTICAL APPLICATIONS.

We have been considering those conditions that are most prominent in influencing the loss of moisture in cheese and have called attention to the results secured by us. We come now to consider these results in their practical application to the interests of the factory owner, his patrons and the consumers of cheese. In this connection we will discuss the following topics:

(1) Value of water in cheese to dairymen.
(2) Moisture in cheese in relation to commercial quality.
(3) What percentage of moisture should cheese have?
(4) Value of water in cheese to consumer.
(5) Variation of loss of moisture with different kinds of cheese.
(6) Loss of moisture and loss of fat.

VALUE OF WATER IN CHEESE TO DAIRYMEN.

To the cheese-maker and producer of milk, water in cheese is money, when put there in the right way and in proper proportions. It is essential, in the process of manufacture, to incorporate water in cheese in quantities best suited to the requirement of the market for which the cheese is intended, and then it is equally essential that the water be kept there with the least possible loss. From the dairyman's standpoint, it is desirable to sell as much water in cheese as will suit the consumer. In preventing excessive loss of moisture there is more water to sell at cheese prices.

From inquiries made among cheese-makers we find quite a variation in respect to the loss of moisture experienced by them in curing cheese. One of the most complete records, covering an entire season, furnished by a cheese-maker and factory owner who has better than average conditions for curing rooms, makes the average loss of weight during thirty days amount to about five pounds per hundred pounds of cheese. Others report an average loss for the first thirty days as high as ten pounds per hundred pounds of cheese. The average loss lies somewhere between these two extremes and would probably not be far from seven pounds per hundred pounds of cheese.

An examination of Table II shows that the loss of moisture can be reduced to four pounds per hundred pounds of cheese. Using this figure as a basis for calculation, we find that, for every hundred pounds of cheese, from one to six pounds, with an average of three pounds of water could be saved to sell at cheese prices. This would mean an increase of 8 to 48 cents, with an average of 30 cents, received for every hundred pounds of cheese. This would mean an average saving of three hundred dollars a season for a factory with a total season's output of one hundred thousand pounds of cheese. One cheese-maker reports that he calculated one season's loss from shrinkage and found it over six hundred dollars. While such losses may not be regarded as large in comparison with the total receipts, they constitute a noticeable percentage when viewed as a decrease of profits, and are well worth saving.

MOISTURE IN CHEESE IN RELATION TO COMMERCIAL QUALITY.

We have just called attention to increased receipts coming from cheese, as a result of preventing excessive loss of moisture. Such saving of moisture not only increases the amount of cheese to be sold but also increases the value of the cheese from the standpoint of commercial quality.

In Bulletin No. 184, of this Station, Mr. Geo. A. Smith, Dairy Expert, has presented the results of work showing the influence of temperature upon the commercial quality of cheese. No attempt is there made to analyze the results and point out the immediate causes affecting quality, and attention is, therefore, called to the subject here.

The relations existing between moisture and flavor are known only in a very general way. But we know something of the general relation between moisture and texture. Excessive moisture produces undesirable softness, from a commercial standpoint, and at ordinary temperatures favors the formation of holes, a serious fault in the texture of Cheddar cheese. On the other hand, deficient moisture favors the production of a crumbly, dry, mealy texture, which is an undesirable condition.

High temperatures cause excessive loss of moisture and result in the production of crumbly texture. This condition injures the commercial quality of cheese and results in lower prices for such cheese. The following figures represent averages taken from data given on page 202, Bulletin 184, showing the general relation between texture and loss of moisture.

TABLE VIII.—EFFECT OF TEMPERATURE OF CURING ON TEXTURE AND MOISTURE OF CHEESE.

TEMPERATURE OF CURING-ROOM.	Texture of cheese. (Perfect texture is 25.)	Moisture lost by 100 lbs. of cheese.
		Lbs.
55 degrees F.	24.6	8.5
60 degrees F.	24.4	9.0
65 degrees F.	23.6	9.2
70 degrees F.	22.0	10.2
75 degrees F.	21.4	10.7
80 degrees F.	20.6	13.1

WHAT PERCENTAGE OF MOISTURE SHOULD CHEESE HAVE?

Much of the cheese made in New York State contains, in the fresh state, from 36 to 37.5 per ct. of water. The home-trade cheese, much of which is made in the fall, contains 38 to 40 per ct. of water. For the average consumer, it is safe to say, the amount of moisture in cheese should be not less than between 33 and 35 per ct. at the time of consumption. Taking everything into consideration, it is reasonable to expect better results in reference to quality by holding a moderate amount of moisture in the green cheese and so curing as to lose only a small amount of water, than by holding an excessive amount of moisture in the green cheese and so curing as to lose a larger amount of moisture. Some cheese-makers expect that they must lose ten pounds of weight per hundred pounds of cheese in curing, and they attempt to meet this loss by retaining 40 per ct. or more of moisture in the cheese. Such a practice can not lead to good results from any point of view.

A fact that should not be lost sight of in this connection is this: Cheese cured at such low temperatures as are favorable to diminishing the loss of moisture can carry larger amounts of moisture from the start without impairing the quality.

VALUE OF WATER IN CHEESE TO CONSUMERS.

In the first place, cheese that has not lost too much of its moisture is more pleasing to the taste of the average consumer. In the next place, the more completely a cheese dries out, the harder and thicker is the rind and the greater the loss to the consumer. Most people have become accustomed to such a waste, but much of it is unnecessary. In a carefully cured cheese, the rind is comparatively moist and only a very thin portion need be lost, and even this can be used in cooking.

VARIATION OF LOSS OF MOISTURE WITH DIFFERENT KINDS OF CHEESE.

It has been pointed out that cheeses of small size lose more moisture per hundred pounds than do cheeses of larger size. In making small cheeses like "Young Americas" the proportion of loss is much greater, and hence the demand is still more imperative that these shall be cured under conditions where the loss of moisture shall be greatly reduced. This applies also to such sizes as "Flats" and "Twins." It is not surprising that the manufacture of small cheeses of the Cheddar type has been discouraged. Even at the higher prices that they bring, the extra loss of moisture and additional cost of manufacture are not satisfactorily covered. In the manufacture of small fancy kinds of soft cheese, these statements do not apply, because an essential part of the equipment consists of curing-cellars of fairly low temperature and high moisture content.

LOSS OF MOISTURE AND LOSS OF FAT.

High temperatures, which favor increased loss of moisture, also favor loss of fat by exudation from the surface of the cheese. When cheese is kept at a constant temperature even of 70° F., there is evidence of some, though small, loss. At 75° F. the loss becomes considerable and increasingly large with increase of temperature above 75° F.

V. PREVENTION OF LOSS OF MOISTURE IN CURING CHEESE.

From the data previously presented, it has been seen that loss of weight in cheese curing is due to lack of control of temperature and moisture in the curing-room. Three methods or systems have been proposed for the purpose of controlling these conditions or obviating the need of controlling them:

(1) Immediate sale and removal of green cheese.

(2) Central curing-rooms for the use of several factories.

(3) Special curing-room in each factory.

IMMEDIATE SALE AND REMOVAL OF GREEN CHEESE.

It was formerly a common custom to keep cheese at the factory for thirty days or more before selling it. For some time there has been a tendency to dispose of cheese at more frequent intervals, sales and shipments being made, in some cases, of cheese a week old. There appears to be an increasing desire to place cheese in the hands of buyers just as soon as they were willing to take it. Many buyers who have cold-storage facilities prefer to remove the cheese from the factory before it has had a chance to deteriorate under the adverse conditions of curing commonly present in factory curing-rooms. The system of removing cheese by buyers from the factory when less than a week old has the advantage for the cheese-maker of relieving him from all responsibility in relation to the curing process. There is, however, under such a plan the disadvantage of turning over to the buyer all the advantage that comes from increase of value as a result of good curing. With proper curing facilities, the cheese could be retained by the factory and held until it had increased very materially in value as a result of curing under good conditions. When cheese is sold green, or nearly so, the opportunity for increased profits, due to proper curing, is wholly lost.

CENTRAL CURING-ROOMS.

Four or five years ago Drs. Babcock and Russell made the suggestion that buildings, centrally located with reference to

several cheese factories, be erected especially for curing purposes and designed to take care of the product of the several factories. Such a system has several advantages: (1) Enough money could be easily secured to build and equip a central curing-house that would be complete in its details and thoroughly efficient for controlling temperature and moisture. In fact, ideal conditions could be assured. No single factory could afford to provide itself an equally effective curing-room, or would be likely to do so. The cost for one central cheese-curing building, distributed among several factories, would be no more than would the cost of providing an inefficient curing-room in each individual factory. (2) Cheese stored in a central curing-house could receive more skillful and efficient attention than it could in curing-rooms located in each factory. (3) The cheese could be examined more economically by buyers, being collected in large quantities in a central curing-house. The buyer would be saved the necessity of visiting each factory separately. (4) The maximum saving could be effected in decreasing loss of moisture and in improving quality of cheese. Moreover, the cheese from any one factory or any number of factories would be more uniform in character when cured than under present conditions, or even with curing-rooms in individual factories. (5) Cheese kept under ideal conditions during the curing process can be held subject to market conditions without risk of injury in respect to quality. Under the conditions commonly prevailing, cheese has to be sold to avoid the injury in quality that might result from longer holding at the factory. This is especially applicable in hot weather, a time when prices are likely to be lowest. Cheese kept in proper curing-rooms can be held for higher prices and will constantly improve in quality for quite a long period of time.

SPECIAL CURING-ROOM IN EACH FACTORY.

When it is impossible to coöperate with other factories in the construction and use of a central cheese-curing building, then it is desirable that one shall make a cheese-curing room in the

factory, even though the results secured may not be perfect. Some attempt to control temperature and moisture in curing cheese will give better results than are possible in the absence of any system, a condition too general at present in the cheese factories of New York.

The subject of a special curing-room in each cheese factory has been very fully discussed in Bulletin No. 70 of the Wisconsin Agricultural Experiment Station, and several factories in that State have made such curing-rooms. The system has also been studied and applied in Canada by Prof. James Robertson, Commissioner of Agriculture and Dairying for the Dominion.

The following statements are, for the most part, condensed from Prof. F. H. King's Wisconsin Bulletin No. 70. The cuts are from the same source.

Curing-rooms may be constructed above ground or under ground, and may be of wood or masonry or a combination. Considering moderate cost, convenience, and efficiency, a curing-room built of wood entirely above ground is the most practical for the average factory.

(1) *Location.*—A curing-room above ground should be placed on the north side of a building in order to be protected as much as possible from the direct rays of the sun. It is advantageous also if the room can be shut off on the other three sides by hallways, stairways, other rooms or building screens.

(2) *Windows* in a curing-room should be as few and as small as consistent with the amount of light necessary. They should be made double, as nearly air-tight as possible, and preferably in one section, fitted closely and permanently in place. If necessary to exclude direct sunshine, blinds or awnings should be placed outside.

(3) *The door* of a curing-room should be built to resemble that of a refrigerator.

(4) *Walls* should be built like those of cold-storage and ice-houses. The studding outside should be covered with matched sheathing and drop siding, with a layer of three-ply acid and water-proof paper between. The paper recommended by Prof.

King is manufactured by the Standard Paint Co., New York and Chicago. On the inside a layer of matched sheathing is nailed to the studding, then strips of inch furring two inches wide, to which are nailed two thicknesses of matched sheathing with paper between. The outer air space between the studding is filled with sawdust or similar material, and the spaces left by the furring are closed air-tight at the ceiling and floor. (See Plate VII.)

(5) *Ceiling and floor* should also consist of two thicknesses of matched lumber with paper between, and joints made at corners should be very tight.

In constructing curing-rooms two things should be kept in mind: First, that the walls should be as nearly air-tight as possible in order to keep out the warmer air outside, and, second, that the walls should be poor conductors of heat. It is advantageous to cover the inside walls with two coats of shellac.

(6) *Ventilating flue in ceiling.*—It is desirable to provide a tight ventilating flue in the ceiling of the curing-room, extending above the roof. Its diameter may be six or eight inches. It should be provided with a damper. (See Plate VIII, H, I.)

(7) *Methods of controlling temperature and moisture in cheese curing-rooms placed above ground.*—After constructing a proper curing-room, it is essential to provide arrangements for controlling temperature and moisture. The construction of a curing-room is only a partial means toward this end. The following methods have been found effective in keeping the temperature during summer between 58° and 70° F. and at the same time modifying the moisture content of the air favorably: (a) Ventilation by air forced through horizontal sub-earth ducts or deep vertical sub-earth ducts and wells. (b) Ventilating over ice. (c) Evaporation of water.

Plate VIII illustrates the construction of a horizontal sub-earth duct, which should be 12 feet or more below the surface of the ground and 100 feet or more in length. It is recommended that the sub-earth duct consist of three rows of 10-inch drain tile laid side by side at the bottom of the trench, or the

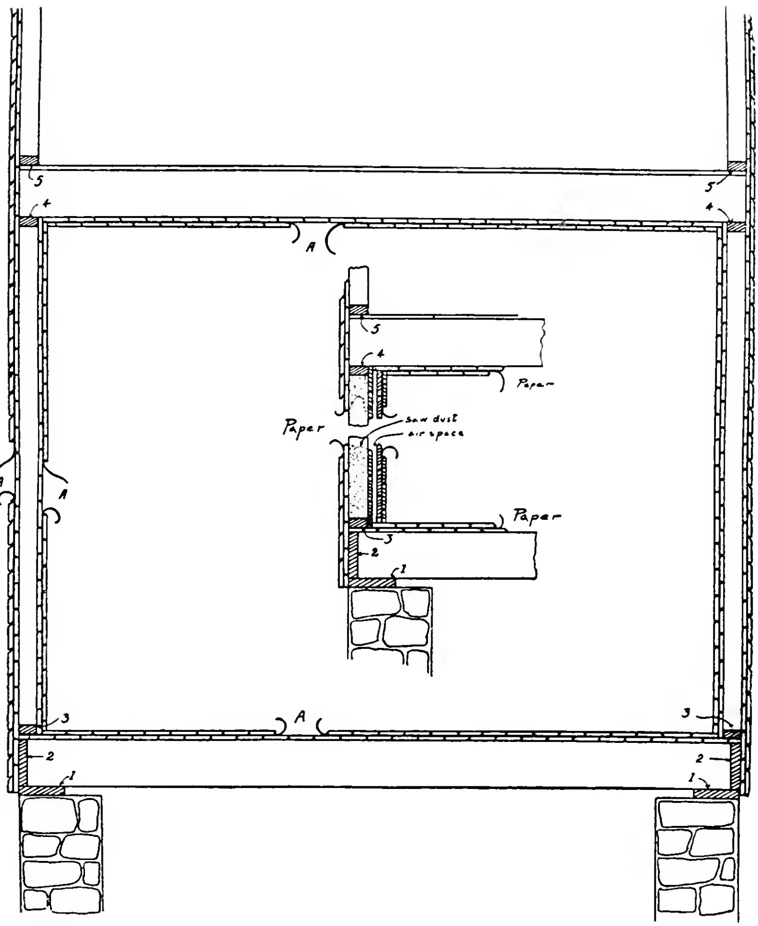


Plate VII.—Showing the construction of wood curing-room: 1, 1, 1, sill; 2, 2, 2, a two-by-ten spiked to ends of joist; 3, 3, 3, a two-by-four spiked down, after first layer of floor is laid, to toe-nail studs to; 4, 4, 4, a two-by-four spiked to upper ends of studding of first story. A, A, A, A, three-ply acid and waterproof paper. The drawing in the center shows space between studding filled with sawdust and another dead-air space to be used when the best ducts cannot be provided. (From Wis. Agr. Exp. Sta. Bul. 70.)

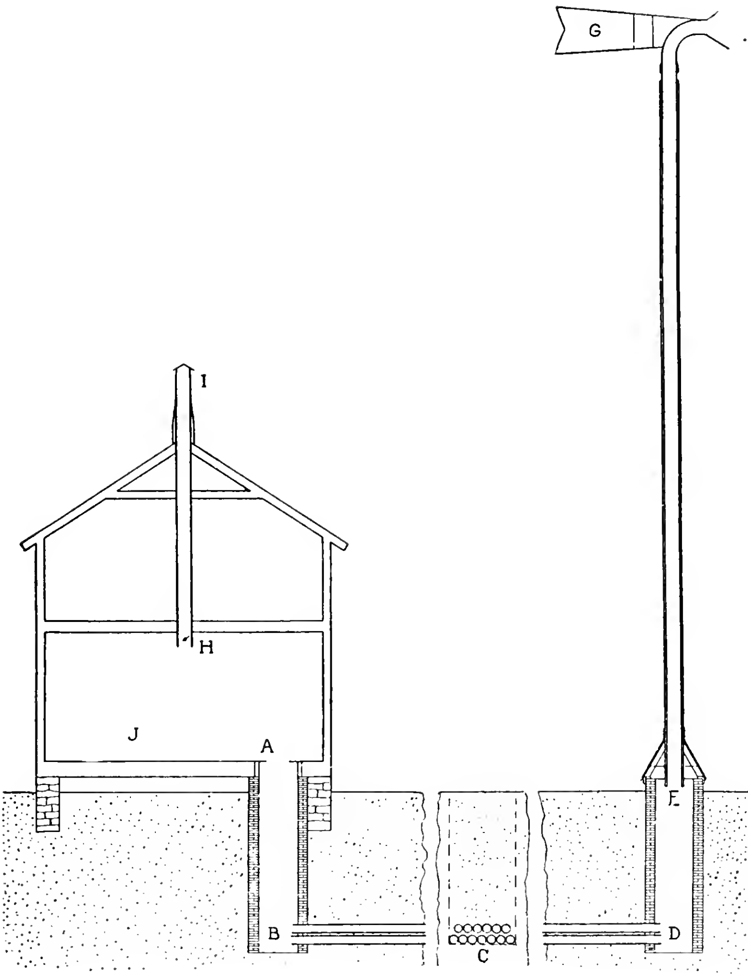


Plate VIII.—Section of cheese-curing room and horizontal multiple sub-earth duct. A, inlet to curing room; B, end of sub-earth duct in bricked entrance to factory; C, cross-section of the multiple ducts; D, E, bricked entrance under funnel at outer end of sub-earth duct; F, funnel with mouth 36 inches across; G, vane to hold funnel to the wind; H, ventilating flue with damper. (From Wis. Agr. Exp. Sta. Bul. 70.)

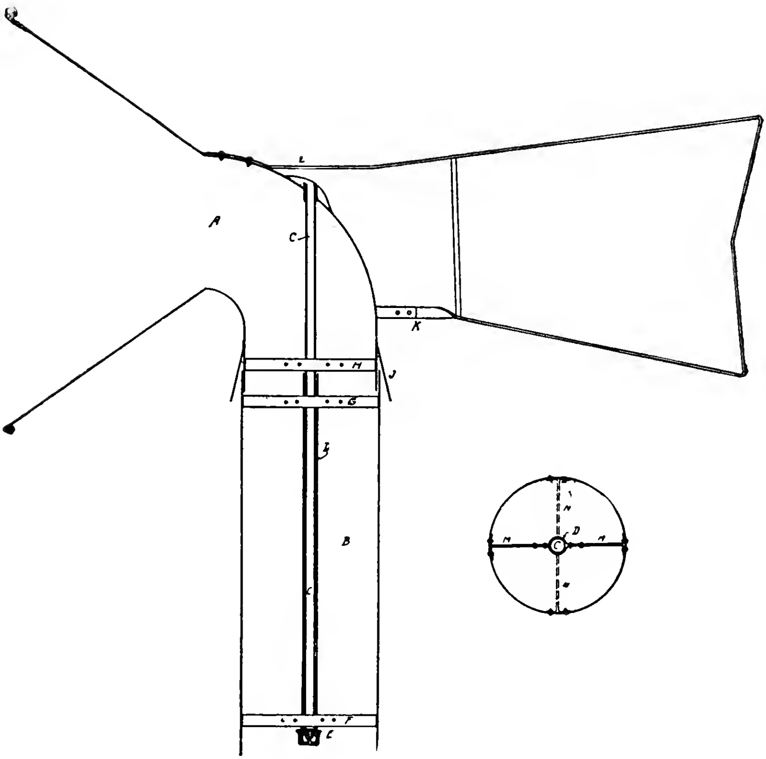


Plate IX.—Showing how funnel and vane may be mounted. A, funnel; B, shaft of funnel; C, C, C, 1-inch gas pipe; D, D, 1¼-inch gas pipe; E, cap for support of 1-inch gas pipe; F, G, H and M M and N N are stays of band iron bolted together and to the sides of the shaft to support the axis of the funnel; J, weather collar to turn rain out of shaft; K, L, band-iron to stiffen vane and attach it to funnel. (From Wis. Agr. Exp. Sta. Bul. 70.)

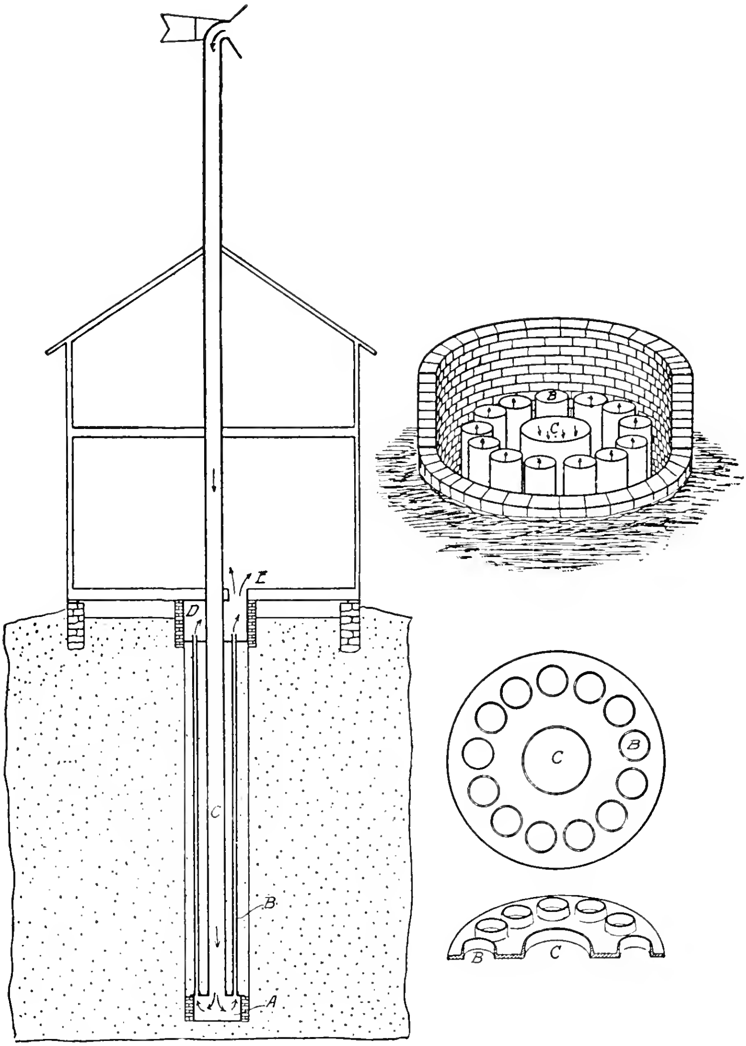


Plate X.—Showing vertical sub-earth duct. A, brick chamber 25 to 30 feet below surface and 40 inches inside diameter; B, tile or conductor pipe of galvanized iron; C, main shaft of funnel; D, brick chamber at upper end of duct. The circle and section represent a cast-iron plate to cover brick chamber A, and can be had of King & Walker, Madison, Wis. (From Wis. Agr. Exp. Sta. Bul. 70.)

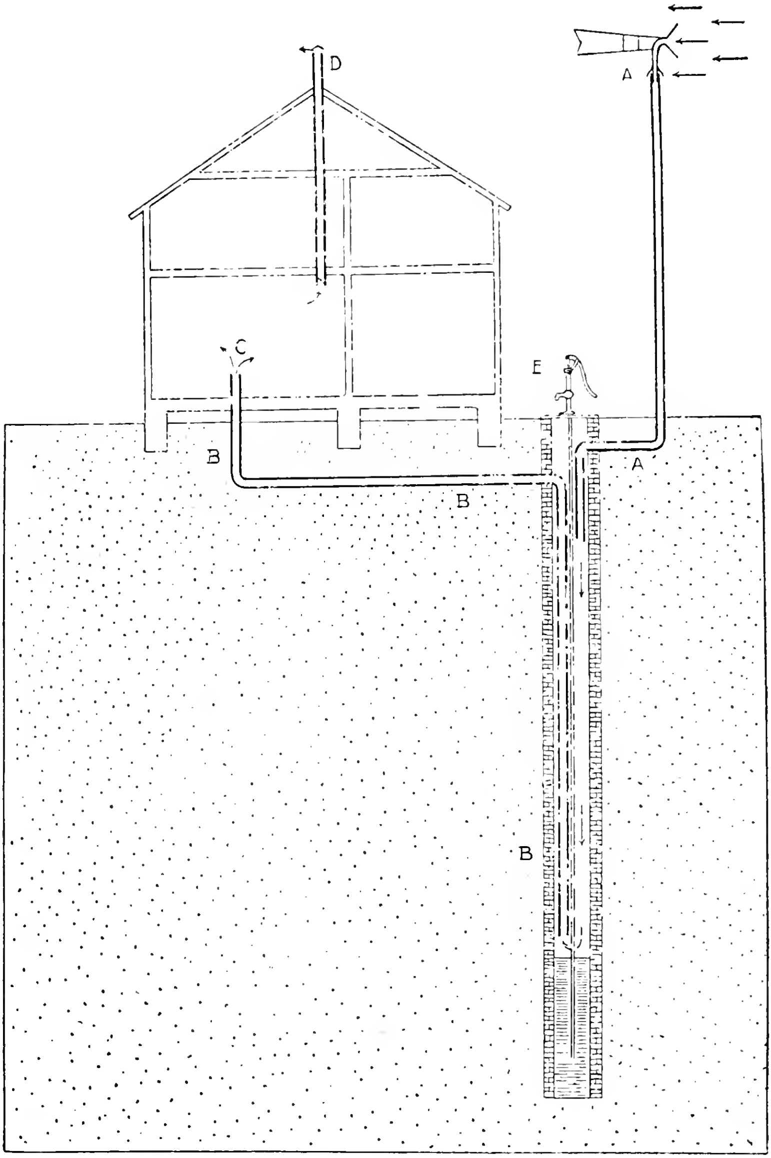


Plate XI.—Showing vertical section of factory and sub-earth duct in well. A, A, funnel taking air into well; B, B, duct leading air from wall to curing room, C; D, ventilator. (From Wis. Agr. Exp. Sta. Bul. 70.)

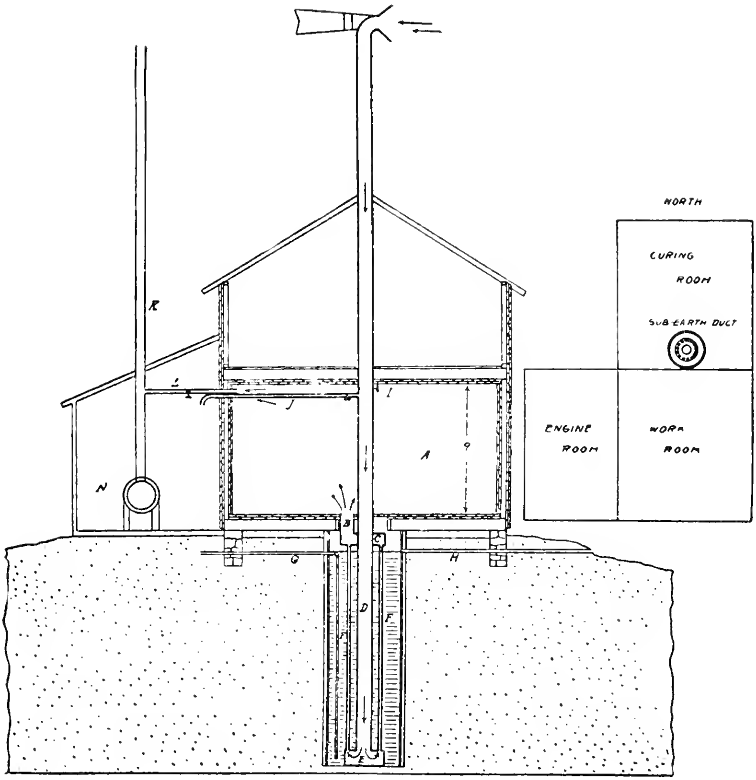


Plate XII.—Showing method of cooling air with cold water. A, curing room; B, duct leading into curing room; C, E, galvanized iron drums, air and water tight; F, thirteen or more 5-inch flues of galvanized iron, 10 ft. long, soldered water tight to drums to cool air; D, main air duct from funnel; G, water pipes from pump; H, overflow pipe; I, damper in main shaft; J, 4-inch pipe leading from blower to use when there is no wind; K, smokestack of boiler; L, ventilator from curing room to smokestack; N, boiler. (From Wis. Agr. Exp. Sta. Bul. 70.)

trench may be dug narrower and one or two feet deeper and the tile placed one above the other. The shaft for carrying the funnel must be made tight; it may be 12 inches square, if made of plank, or 12 inches in diameter, if made of galvanized iron. The height should be sufficient to enable the funnel to catch the wind readily. The construction and mounting of the funnel are illustrated in Plate IX. The extreme diameter of the funnel should be about 36 inches.

The inlet from the sub-earth duct into the curing-room must be provided with some arrangement of valves that will permit the air to be shut off wholly or partly. Too rapid entrance of air in warm weather will not permit enough cooling during passage through the duct. In case of dry winds, too rapid entrance would reduce the moisture too much.

In Plate X there is illustrated a deep vertical sub-earth duct. Such a duct has the advantage of requiring less piping and also less wind will suffice to produce a current of air. The vertical duct should have a depth of not less than twenty-five or thirty feet, provided water is far enough from the surface. Thirteen lines of 6-inch drain or 5-inch galvanized iron conductor pipe may be used and placed as in the cut. The duct should be located near the north end of the curing-room or directly beneath it. A hanging platform can be used in placing the pipes or tubes in position and the earth packed carefully around the pipes. An excavation of proper size, made as for an ordinary well, will answer the purpose. After the duct has been placed in position the earth that has been removed can be used for filling around the duct.

In Plate XI there is represented a duct connected with a well of water. In the particular instance illustrated, the well is 64 feet deep; the intake pipe is 10 inches in diameter, rising just barely above the roof of the factory, entering the well, as shown at A, two feet below the surface of the ground and then descending inside the well a distance of 8 feet. Another 10-inch galvanized iron pipe starts 40 feet below the surface of the ground and rises to within 5 feet of it, when it turns and passes hori-

zontally until it comes under the curing-room which it enters directly, as shown at B B B C. The top of the well is tightly closed.

In Plate XII the cut illustrates the cooling of air in a curing-room by forcing the air through cold water. When the ground water is within 12 or 15 feet of the surface, then a cistern 5 or 6 feet in diameter, shaped like a well, may be built, plastering with cement as in the case of ordinary cisterns. In this cistern can be placed an air duct made of galvanized iron as given in Plate XII. The duct should be water-tight. By connecting the cistern with the well, fresh water may be added from time to time as may be found necessary to keep water sufficiently cool to be effective.

In Canada, considerable work has been done in using ice in curing rooms to control temperature. Where ice can be obtained conveniently and cheaply, this method may be advantageously utilized. One or more ice boxes are placed in the curing-room, so built that air can circulate about the ice and into the curing-room. Also compartments, filled with ice, may be made adjoining the curing-room on the side or above, provided with openings into the curing-room which will allow a flow of air over the ice and into the curing-room.

Where special means are needed to secure moisture, this can be effectively done by means of yard-wide strips of any cloth material that has good capillary power. The pieces of cloth are hung about the room and kept more or less saturated with water. Experience will tell how much evaporating surface is needed to provide the degree of moisture needed.

TABLE SHOWING PERCENTAGE OF SATURATION OF MOISTURE IN AIR AT VARIOUS TEMPERATURES ACCORDING TO HYGROMETER.

Dry thermometer. Degrees Fahrenheit.	Difference between the dry and wet thermometers in degrees Fahrenheit.																						
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0
	Percentages of moisture in air.																							
40	96	92	88	84	80	76	72	68	64	60	56	53	49	45	41	38	34	30	26	22	19	16	12	8
41	96	92	88	84	80	76	72	69	65	61	57	54	50	46	43	39	36	32	29	24	21	18	11	10
42	96	92	88	81	81	77	73	69	65	62	58	55	51	48	44	40	37	34	30	27	23	20	16	13
43	96	92	88	85	81	77	74	70	66	63	59	56	52	49	46	42	38	35	32	29	25	22	19	15
44	96	92	88	85	81	78	74	70	67	63	60	57	53	50	47	43	40	37	33	30	27	24	21	17
45	96	92	89	85	82	78	75	71	67	61	61	58	54	51	48	44	41	38	35	32	29	25	22	19
46	96	93	89	85	82	79	75	72	68	65	61	58	55	52	49	46	42	39	36	33	30	27	23	21
47	96	93	89	86	88	79	76	72	69	66	62	59	36	53	50	47	44	40	38	34	31	28	25	22
48	96	93	89	86	83	79	76	73	69	66	63	60	56	53	51	48	45	42	39	36	33	30	27	24
49	97	93	90	86	83	80	76	73	70	67	63	60	57	54	52	49	46	43	40	37	34	31	29	26
50	97	93	90	87	83	80	77	74	70	67	64	61	58	55	52	50	47	44	41	38	36	33	30	27
51	97	93	90	87	84	81	77	74	71	68	65	62	59	56	53	50	48	45	42	39	37	34	31	28
52	97	94	90	87	84	81	78	75	72	69	66	63	60	57	54	51	48	46	43	40	38	35	33	30
53	97	94	91	87	84	81	78	75	72	69	66	63	61	58	55	52	49	47	44	42	39	36	34	31
54	97	94	91	88	85	82	79	76	73	70	67	64	61	59	56	53	50	48	45	43	40	38	35	32
55	97	94	91	88	85	82	79	76	73	70	68	65	62	59	57	54	51	49	46	43	41	39	36	34
56	97	94	91	88	85	82	80	77	74	71	68	65	63	60	57	55	52	50	47	44	42	40	37	35
57	97	94	91	88	86	83	80	77	74	71	69	66	64	61	58	55	53	50	48	45	43	40	38	36
58	97	94	91	89	86	83	80	78	75	72	69	67	64	61	59	56	53	51	49	46	44	42	39	37
59	97	94	92	89	86	83	81	78	75	72	70	67	65	62	60	57	54	52	49	47	45	43	40	38
60	97	94	92	86	86	84	81	78	75	73	70	68	65	63	60	58	55	53	50	48	46	44	41	39
61	97	94	92	89	87	84	81	78	76	73	71	68	66	63	61	58	56	54	51	49	47	41	42	40
62	97	95	92	89	87	84	82	79	76	74	71	69	66	64	61	59	57	54	52	50	47	45	43	41
63	97	95	92	89	87	84	82	79	77	74	72	69	67	64	62	60	57	55	53	51	48	46	44	42
64	97	95	92	90	87	85	82	79	77	74	72	70	67	65	62	60	58	56	53	51	49	47	45	43
65	97	95	92	90	87	85	82	80	77	75	72	70	68	65	63	61	59	56	54	52	50	48	46	44
66	97	95	92	90	87	85	82	80	78	75	73	71	68	66	63	61	59	57	55	53	51	49	47	45
67	98	95	93	90	88	85	83	80	78	76	73	71	69	66	64	62	60	58	55	53	51	49	47	45
68	98	95	93	90	88	86	83	81	78	76	74	71	69	67	65	63	60	58	56	54	52	50	48	46
69	98	95	93	90	88	86	83	81	78	76	74	72	70	67	65	63	61	59	57	55	53	51	49	47
70	98	95	93	90	88	86	83	81	79	77	74	72	70	68	66	64	62	60	57	55	53	52	50	48
71	98	95	93	91	88	86	84	81	79	77	75	72	70	68	66	64	62	60	58	56	54	52	50	48
72	98	95	93	91	88	86	84	82	79	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49
73	98	95	93	91	88	86	84	82	80	78	75	73	71	69	67	65	63	61	59	57	55	53	52	50
74	98	95	93	91	88	86	84	82	80	78	76	74	72	70	68	66	64	62	60	58	56	54	52	50
75	98	95	93	91	89	87	84	82	80	78	76	74	72	70	68	66	64	62	60	58	56	55	53	51
76	98	95	93	91	89	87	85	82	80	78	76	74	72	70	68	66	61	63	61	59	57	55	53	52
77	98	95	93	91	89	87	85	83	80	78	76	74	72	71	69	67	65	63	61	59	57	56	54	52
78	98	96	93	91	89	87	85	83	81	79	77	75	73	71	69	67	65	63	62	60	58	56	51	53
79	98	96	94	91	89	87	85	83	81	79	77	75	73	71	70	68	66	64	62	60	58	57	55	53
80	98	96	94	92	89	87	85	83	81	79	77	75	73	72	70	68	66	64	63	61	59	57	55	54

REPORT

ON

Crop Production.

W. H. Jordan, *Director.*

G. W. Churchill, *Agriculturist.*

F. A. Sirrine, *In charge of Second Judicial Department Experiments.*

Table of Contents.

INFLUENCE OF MANURE UPON SUGAR BEETS.*

W. H. JORDAN AND G. W. CHURCHILL.

SUMMARY.

(1) These experiments were undertaken to test the accuracy of the statement that sugar beets are of an inferior quality when grown on land to which stable manure is applied in the spring.

(2) The experiments have been conducted during four consecutive years, mostly on the Station farm. Comparisons have been made of the quality of beets not manured, those grown with commercial fertilizer, mostly 1,000 lbs per acre, and those grown on land receiving in the spring, before planting the beets, from 40,000 lbs. to 80,000 lbs. stable manure per acre. Beets from at least six varieties of seed were grown during the four years.

(3) The results are almost unanimous in one direction. The beets have been of high quality with all three methods of treatment, averaging somewhat better with the farm manure than with no manure or with commercial fertilizers.

INTRODUCTION.

The value of a given lot of sugar beets for sugar-making purposes depends chiefly upon two factors, viz.: the percentage of saccharose in the beets and the percentage and character of the soluble compounds accompanying the sugar. In general a beet is valuable in proportion to its content of crystallizable sugar, but if this is attended by too large an amount of certain soluble non-sugars, the effect is to prevent the crystallization of some of the saccharose which under better conditions would be secured in the manufactured product.

*A reprint of Bulletin No. 205.

The relation of crystallizable sugar to the total solids in solution in the juice of beets is known as the coefficient of purity.

It is generally taught that the percentage of sugar in beets and also the coefficient of purity are materially influenced by the kind and amount of fertilizing material which is used in growing the crop. Growers are especially cautioned against planting beets on land freshly fertilized with stable manure and against heavy nitrogenous manuring with chemicals. It is stated that past experience has shown that beets raised where a generous application of farm manure is made in the spring are inferior for manufacturing purposes, and it is suggested that while a large application of nitrate of soda may not cause a diminution of the sugar content it may so lower the coefficient of purity as to lessen materially the proportion of available sugar.

In 1898 experiments conducted by this Station in growing beets with the use of farm manures and with commercial fertilizers in varying quantities gave results in apparent conflict with prevailing views.[1] These results have led to the continuation, during the past three years, of experiments of a similar character, the outcome of which is presented in this bulletin.

THE EXPERIMENTS.

GENERAL PLAN AND CONDITIONS.

The experiments were planned with reference to comparing the composition of beets grown with commercial fertilizers and those grown with stable manure applied in the spring just before planting. Check plats have also been used in order to ascertain how the beets would grow without the application of any manure whatever. All the experiments have been conducted on the Station farm, excepting in the year 1898, when one set was carried out on the farm of F. E. Dawley, Fayetteville.

Excepting the year 1899, when texture conditions were

[1] N. Y. Agrl. Expt. Sta. Bul. No. 155.

unfavorable on some of the plats, owing to a lack of rain at the time of germination of the seed, the beets were successfully grown, both as to quantity and as to the type and healthfulness of the plants.

The temperature and rainfall as shown by records kept at the Station are of interest in this connection.

TABLE I.—TEMPERATURE AT GENEVA.

Month.	1898. Max.	1898. Min.	1898. Av.	1899. Max.	1899. Min.	1899. Av.
	Deg.	*Deg.*	*Deg.*	*Deg.*	*Deg.*	*Deg.*
April	52.7	33.6	43.2	56.8	36.3	46.6
May	65.5	47.4	57	68.7	46.4	57.6
June	78.2	57.2	67.7	82.3	56.6	69.5
July	86.5	61.8	74.2	82.9	59.5	71.2
August	80.6	61.4	71	83.9	59.2	71.6
September	77.1	54.7	65.9	71.1	50	60.6
October	61.4	42.8	52.1	63.8	42.9	53.4

Month.	1900. Max.	1900. Min.	1900. Av.	1901. Max.	1901. Min.	1901. Av.
	Deg.	*Deg.*	*Deg.*	*Deg.*	*Deg.*	*Deg.*
April	52.7	34.2	43.5	56	37.1	46.5
May	68.5	44.9	56.7	67	46.8	56.9
June	81.4	55.4	68.4	80.5	57.4	68.9
July	83.2	62	72.6	88.2	65.1	76.6
August	85	63.1	74.1	80.9	61.1	71
September	78.9	53.3	66.1	75	53	64
October	68.4	47.4	57.9	62.1	47	51.4

TABLE II.—PRECIPITATION AT GENEVA.

Month.	1898.	1899.	1900.	1901.
	In.	*In.*	*In.*	*In.*
March	1.54	1.22	.02	2.19
April	2.03	1.12	.95	4.43
May	1.90	1.69	1.71	3.80
June	2.39	1.71	1.45	2.07
July	1.32	4.15	6.53	3.97
August	3.60	1.05	1.75	5.62
September	1.86	2.23	.91	2.46
October	3.83	2.69	3.65	1.35
Totals eight months	18.47	15.86	16.97	25.89
Total for May, June, July and August	9.21	8.60	11.44	15.46

Attention is called to the great variations in the rainfall during the four months most important in the life of the plants. In 1899 there was a deficiency in available water but not in 1901.

The soil of the Station farm is a strong clay loam, well adapted to general farming and capable of producing large crops when well handled.

The plats used in the beet experiments could not be regarded as especially deficient in fertility, and would not respond to the application of manures as would poorer land.

The methods used in the cultivation of the crop were those approved by past practice and no detailed statement concerning them is necessary in this connection.

THE MANURE.

The stable manure used was a mixture of that coming from the cow and horse stables of the Station, sufficiently composted and mixed to render it fine and of uniform composition. The manure actually applied to the beet soil was analyzed only one year, 1901. Manure from the same general source and used in another experiment was analyzed in 1897, 1898 and 1899. From the data thus secured it is possible to know approximately the amounts of plant food supplied to the crops from this source.

TABLE III.—COMPOSITION OF MANURE MADE IN THE STATION STABLES.

Year.	Water.	Nitrogen.	Phosphoric acid.	Potash.	
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	
1897	73.9	.389	.360	.342	Used on corn.
1898	76.1	.363	.241	.593	Used on corn.
1899	74.3	.529	.576	.851	Used on wheat.
1901	78.3	.445	.382	.738	Used on beets.

In 1901 the manure was applied at the rate of 80,000 lbs. per acre, in all other years at the rate of 40,000 lbs.

The commercial fertilizer mixture was essentially the same throughout. Its ingredients and approximate composition are given in Table IV.

TABLE IV.—FERTILIZER MIXTURE USED ON SUGAR BEETS.

Material.	In one ton.	Containing approximately— Nitrogen.	Phosphoric acid.	Potash.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Acid phosphate	900	......	126	......
Sulphate of potash	300	......	......	150
Dried blood	400	40	8	......
Nitrate of soda	400	60	......	......
Total	2000	100	134	150
In 1000 lbs. of the mixture	......	50	67	75
In percentages	......	5	6.7	7.5

EXPERIMENTS OF 1898.[1]

These were carried on both on the Station farm and on the farm of F. E. Dawley, Fayetteville, N. Y. The plats were 1-12 acre at the Station and at Mr. Dawley's 1-16 acre. In the tables which follow the yields are given for one acre.

TABLE V.—COMMERCIAL FERTILIZERS ON SUGAR BEETS, 1898.

Amount of fertilizer used.	Yield of trimmed and washed beets per acre.	Sugar in beets.[2]	Coefficient of purity of juice.	Average weight of beets analyzed.	Place of experiment.
Lbs.	*Lbs.*	*Per ct.*		*Ozs.*	
0	20,425	15.2	85.2	16½	Station.
500	21,375	15.6	85.7	16½	Station.
500	27,140	14.5	86.0	15	Station.
1000	26,928	14.4	83.6	20	Station.
1000	26,250	14.7	85.4	16	Station.
1500	23,822	14.3	84.5	17	Station.
1500	27,920	14.9	85.8	15½	Station.
2000	22,073	15.0	85.6	16½	Station.
2000	27,875	17.0	87.1	13½	Station.
0	18,585	15.4	81.6	12½	Fayetteville.
0	17,740	17.2	85.0	9	Fayetteville.
500	23,373	15.2	77.1	14½	Fayetteville.
500	24,075	14.3	79.8	16½	Fayetteville.
1000	24,220	14.5	78.3	13½	Fayetteville.
1000	24,220	15.9	81.3	10	Fayetteville.
1500	26,890	15.3	80.1	18½	Fayetteville.
1500	26,330	15.2	79.7	13½	Fayetteville.

[1] Reported in Bulletin No. 155.

[2] The percentages of sugar in the beets as given in the bulletins are the results of actual determinations on the basis of a weighed quantity of beet and are not calculated from the sugar in the juice.

TABLE VI.—SUMMARY SHOWING EFFECT OF FERTILIZERS ON YIELD OF SUGAR BEETS IN 1898.

Fertilizer used per acre.	Number of experiments.	Yield per acre.			
		Lowest.	Highest.	Average.	Increased average.
Lbs.		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
0	3	17,740	20,425	19,294	———
500	4	21,375	27,140	23,990	4,696
1000	4	24,220	26,928	25,405	6,111
1500	4	23,822	27,920	26,240	6,946
2000	2	22,073	27,875	24,974	5,680

TABLE VII.—SUMMARY SHOWING EFFECT OF FERTILIZERS UPON PERCENTAGE OF SUGAR IN BEETS IN 1898.

Fertilizer used per acre.	Number of experiments.	Amount of sugar in beets.		
		Lowest.	Highest.	Average.
Lbs.		*Per ct.*	*Per ct.*	*Per ct.*
0	3	15.2	17.2	15.9
500	4	14.3	15.6	14.9
1000	4	14.4	15.9	14.9
1500	4	14.3	15.3	14.9
2000	2	15.0	17.0	16.0

TABLE VIII.—SUMMARY SHOWING EFFECT OF FERTILIZERS UPON COEFFICIENT OF PURITY OF SUGAR BEETS IN 1898.

Fertilizer used per acre.	Number of experiments.	Coefficient of purity.		
		Lowest.	Highest.	Average.
Lbs.				
0	3	81.6	85.2	83.9
500	4	77.1	86.0	82.1
1000	4	78.3	85.4	82.1
1500	4	79.7	85.8	82.5
2000	2	85.6	87.1	86.3

TABLE IX.—RESULTS OF APPLYING STABLE MANURE IN GROWING SUGAR BEETS, 1898.

Amount of stable manure applied per acre.	Yield of trimmed and washed beets.	Sugar in beets.	Coefficient of purity of juice.	Average weight of beets analyzed.	Distance between beets in row.	Place of experiment.
	Lbs.	*Per ct.*		*Ozs.*	*In.*	
0.........	20,425	15.2	85.2	16½	8	Station.
20 tons....	25,360	18.5	85.2	12	6	Station.
20 tons....	29,340	17.2	86.2	13	8	Station.
20 tons....	28,690	16.4	86.7	15	10	Station.
20 tons....	27,100	15.7	85.2	11	6	Station.
20 tons....	28,354	16.2	85.7	12½	8	Station.
20 tons....	28,630	17.2	87.4	13	10	Station.
20 tons....	29,656	17.8	86.4	11	6	Station.
20 tons....	29,533	17.9	87.7	14	8	Station.
20 tons....	31,944	17.7	87.8	12	10	Station.
0.........	16,050	14.4	77.8	13½	8	Fayetteville.
0.........	18,022	15.5	82.0	16	8	Fayetteville.
20 tons....	23,514	18.2	81.3	8½	8	Fayetteville.
20 tons....	25,625	15.7	78.8	11½	8	Fayetteville.
20 tons....	24,780	13.1	78.0	14½	8	Fayetteville.
20 tons....	25,485	14.3	79.0	11½	8	Fayetteville.
20 tons....	27,034	15.2	80.3	15½	8	Fayetteville.
20 tons....	26,750	17.9	87.5	12½	8	Fayetteville.

TABLE X.—SUMMARY SHOWING EFFECT OF STABLE MANURE ON YIELD OF SUGAR BEETS, 1898.

Amount of stable manure used per acre.	Number of experiments.	Yield per acre.			
		Lowest.	Highest.	Average.	Increased average.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
0..................	3	16,050	20,425	18,730	———
20 tons.............	15	23,514	31,944	27,450	8,720

TABLE XI.—SUMMARY SHOWING EFFECT OF STABLE MANURE ON PERCENTAGE OF SUGAR IN SUGAR BEETS, 1898.

Amount of stable manure used per acre.	Number of experiments.	Amount of sugar in beets.		
		Lowest.	Highest.	Average.
		Per ct.	*Per ct.*	*Per ct.*
0...............................	3	14.4	15.5	15.1
20 tons..........................	15	13.1	18.5	16.6

TABLE XII.—SUMMARY SHOWING EFFECT OF STABLE MANURE UPON COEFFICIENT OF PURITY OF SUGAR BEETS, 1898.

Amount of stable manure used per acre.	Coefficient of purity.		
	Lowest.	Highest.	Average.
0.....................................	77.8	85.2	82.6
20 tons................................	78.0	87.8	84.2

EXPERIMENT OF 1899.

This was similar in plan to those of 1898 and was conducted on the Station farm. As before stated, the crop was a failure on part of the plats, owing to a failure of the seed to germinate. Only on the check plat and on the plats to which farm manure was applied was there a uniform stand of plants. Because of lack of rain at critical times the crop was reduced below the normal. The seed was sown June 1 and the crop was harvested November 22. The plats were 1-36 acre in area. To avoid error, 20 beets from each plat were analyzed.

TABLE XIII.—SUGAR BEETS GROWN WITH STABLE MANURE, 1899.

Plat No.	Stable manure applied per acre.	Yield trimmed beets per acre.	Sugar in beets.	Coefficient of purity.	Average weight of beets.	Distance apart of beets.
		Lbs.	*Per ct.*	*Per ct.*	*Ozs.*	*In.*
11	0...............	15,840	14.8	84.2	10	..
12	20 tons..........	25,200	14.9	83.9	8	6
13	20 tons..........	23,400	15.7	85.9	8.7	8
14	20 tons..........	21,960	15.1	85.7	10.4	10
15	20 tons..........	22,320	15.4	83.3	8.7	6
16	20 tons..........	22,320	15.5	84.6	9.5	8
17	20 tons..........	21,020	16	86	11.2	10
18	20 tons..........	23,940	15.8	86.9	7.7	6
19	20 tons..........	21,800	16.3	88.1	10.3	8
20	20 tons..........	22,680	15.8	90.2	11.7	10

TABLE XIV.—SUMMARY SHOWING EFFECT OF STABLE MANURE ON THE YIELD AND COMPOSITION OF SUGAR BEETS, 1899.

Mauuring per acre.	Yield beets per acre.	Sugar in beets.	Coef. of purity.	Distance apart of beets.
	Lbs.	*Per ct.*	*Per ct.*	*In.*
0	15,840	14.8	84.2	..
Stable manure, 20 tons...........	23,820	15.4	84.7	6
Stable manure, 20 tons...........	22,507	15.8	86.2	8
Stable manure, 20 tons...........	21,887	15.6	87.3	10
General average for manure plats.	......	15.6	86.1	..

EXPERIMENT OF 1900.

In the experiment of this year three varieties of beets were grown, the seed of which was supplied by the U. S. Department of Agriculture. Each variety was planted in triplicate plats with commercial fertilizers and the same with stable manure.

The time of planting was June 4 and of harvesting Nov. 23. The dimensions of the plats were 165x6⅞ feet. Twenty beets from each plat were analyzed.

The results appear in Tables XV and XVI.

Table XV.—Results from Manuring Sugar Beets, 1900.

No. Plat.	Variety of beets.	Yield trimmed beets per acre.	Sugar in beets.	Sugar in juice.	Coefficient of purity.	Average weight of beets analyzed.
		Lbs.	Per ct.	Per ct.		Ozs.
	Plats with Commercial Fertilizer, 1000 Lbs. per Acre:					
1	Vilmorins Improved White..	42,568	.....	15.9	83.6	19
2	White Queen of the North..	39,629	.....	16.1	84.8	20
3	Austrian Special Kleinwanzlebener	38,822	.....	14.6	81.6	18
4	Vilmorins Improved White..	40,051	13.4	15.8	83	18
5	White Queen of the North..	35,635	14.9	16.6	84	18
6	Austrian Special Kleinwanzlebener	37,171	14.2	15	84.4	17½
	Plats with Farm Manure, 40,000 Lbs. per Acre:					
7	Vilmorins Improved White..	41,395	.....	16.1	83.7	21
8	White Queen of the North..	38,077	.....	17.6	85.2	19
9	Austrian Special Kleinwanzlebener	40,550	.....	15.7	84.3	19
10	Vilmorins Improved White..	43,968	15.5	16.8	86.2	18
11	White Queen of the North..	38,784	15.4	17.5	83.9	19
12	Austrian Special Kleinwanzlebener	44,851	14.7	16.1	85	20

Table XVI.—Summary Showing Effect of Manure Upon the Yield and Composition of Sugar Beets (by Varieties), 1900.

Varieties and manures.	Yield per acre.	Sugar in beet.	Sugar in juice.	Coefficient of purity.
	Lbs.	Per ct.	Per ct.	
Commercial Fertilizer, 1000 Lbs. per Acre:				
Vilmorins Improved White.............	41,310	13.4	15.8	83.3
White Queen of the North..............	37,632	14.9	16.3	84.4
Austrian Special Kleinwanzlebener.....	37,996	14.2	14.8	83
Stable Manure, 40,000 Lbs. per Acre:				
Vilmorins Improved White............	42,681	15.5	16.4	85
White Queen of the North..............	39,430	15.4	17.5	84.5
Austrian Special Kleinwanzlebener.....	42,700	14.7	15.9	84.6
General Summary:				
Beets with commercial fertilizers.......	38,979	14.2	15.6	83.6
Beets with stable manure..............	41,604	15.2	16.6	84.7

EXPERIMENT OF 1901.

The seed of the two varieties of beets came from the U. S. Department of Agriculture. Each variety was planted in duplicate on both commercial fertilizer and farm manure plats

TABLE XVII.—RESULTS OF MANURING SUGAR BEETS, 1901.

Plat. No.	Variety and treatment.	Yield of beets per acre. Lbs.	Sugar in beets. Per ct.	Sugar in juice. Per ct.	Coefficients of purity of juice.	Av. weight beets an'lyz'd Ozs.
	DEP'T NO. 6359, MEYERS FRIEDERICKSWERTER:					
1	80.000 lbs. stable manure per acre.	40,710	13.2	14.9	78.1	13.7
2	1000 lbs. commercial fertilizer.....	36,660	12.3	16.5	83.7	14.2
3	No manure......................	25,226	13.1	17.1	82.9	13.9
	DEP'T NO. 5772, DIPPES GERMAN:					
4	80.000 lbs. stable manure per acre.	33,570	13.4	18.6	80	13.1
5	1000 lbs. commercial fertilizer.....	28,190	15.6	20.7	87.7	12

TABLE XVIII.—SUMMARY SHOWING EFFECT OF MANURES UPON YIELD AND COMPOSITION OF SUGAR BEETS, 1901.

	Yield of beets per acre. Lbs.	Sugar in beets. Per ct.	Sugar in juice. Per ct.	Coefficient of purity.
No manure...........................	35,226	13.1	17.1	82.9
1000 lbs. commercial fertilizer..........	32,425	13.9	18.6	85.7
80,000 lbs. stable manure...............	37,140	13.3	16.7	79

In this experiment the commercial fertilizer used was similar to that applied in former years, both in kind and quantity, but the stable manure was increased from 40,000 to 80,000 lbs. per acre. This was an excessive application of an animal manure, twice as much as what most farmers would consider a liberal quantity. Fifty beets from each plat were analyzed. Tables XVII and XVIII show results.

DISCUSSION OF RESULTS.

These experiments, which have been carried through four years, have included the growing of beets from high grade seed from various sources, at least six different varieties (names)

being present. The main question at issue in this work has been the effect of commercial fertilizers and stable manure upon the manufacturing value of the beets, with especial reference to the possibility of depressing the quality of beets by growing them on land to which stable manure has been freshly applied.

A determination of the percentages of sugar and of the coefficients of purity has been the means of judging of the quality of the beets grown. No determination has been made of the character of the non-sugars present in the juice. If beets may be standardized as to quality by the proportion of sugar in them, together with the coefficient of purity, then the conclusions to be drawn from the data herewith presented are plainly indicated. Attention is directed to the figures of the preceding tables but more especially to the general summary in Table XIX.

TABLE XIX.—GENERAL SUMMARY OF RESULTS SHOWING THE INFLUENCE OF MANURE UPON THE QUALITY OF SUGAR BEETS, 1898–1901.

Year grown.	No manure.			Commercial fertilizer.			Stable manure.		
	Sugar in beets.	Sugar in juice.	Coefficient of purity.	Sugar in beets.	Sugar in juice.	Coefficient of purity.	Sugar in beets.	Sugar in juice.	Coefficient of purity.
	Per ct.	*Per ct.*		*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	
1898, Station.	15.2	....	85.2	15	....	85.4	17.2	....	86.5
1898, Dawley	15.6	....	81.6	15	....	79.4	15.9	....	80.8
1899	14.8	16.2	84.2	....	....	....	15.6	17.9	86.1
1900	....	....	....	14.2	15.6	83.6	15.2	16.6	84.7
1901	13.1	17.1	82.9	13.9	18.6	85.7	13.3	16.7	79

The data here presented are strikingly opposed to what is regarded as the orthodox method of manuring sugar beet land. It so happens that, with the exception of the crop of 1901, not only does the stable manure fail to depress the quality of the beets, but the crops grown where it was applied in the spring show a higher percentage of sugar than where commercial fertilizer was used or where no manure was applied. In 1901 the percentage of sugar was but little lower but the coefficient of purity appeared to drop. In this case the stable manure was used in an excessive quantity.

TABLE XX.—INFLUENCE OF MANURES ON THE RELATION OF THE ROOTS AND TOPS OF SUGAR BEETS, 1900, 1901.

Treatment.	Experiment 1900. No. of beets w'hed.	Weight beets with tops. *Ounces.*	Weight beets without tops. *Ounces.*	Per ct. weight of roots. *Per ct.*	Experiment 1901. No. of beets weighed.	Weight beets with tops. *Ounces.*	Weight of beets without tops. *Ounces.*	Per ct. weight of roots. *Per ct.*
Commercial fertilizer plats:								
Plat 1 (2, 1901)	40	761	572	75.1	55	952	778	81.7
Plat 2 (5, 1901)	20	409	309	75.5	55	839	698	83.2
Plat 3	20	369	284	76.9	....	....	....	....
Plat 4	20	367	267	72.7	....	....	....	....
Plat 5	20	351	272	77.5	....	....	....	....
Plat 6	20	365	297	81.4	....	....	....	....
Average	....	....	....	76.5	....	....	....	82.4
Stable manure plats:								
Plat 7 (1, 1901)	40	837	676	80.7	55	926	765	82.6
Plat 8 (4, 1901)	40	778	619	79.6	55	881	735	83.4
Plat 9	40	763	626	82	....	....	....	....
Plat 10	20	354	263	74.3	....	....	....	....
Plat 11	20	318	253	79.5	....	....	....	....
Plat 12	20	435	322	75	....	....	....	....
Average	....	....	....	78.3	....	....	....	83
No fertilizer (3, 1901)	....	....	....	....	55	951	786	82.6
Single beet, commercial fertilizers	....	18.7	14.3	....	....	16.3	13.4	....
Single beet, stable manure	....	19.3	15.3	....	....	16.4	1.36	....

Some indication of the relative effect of the two kinds of manures may be gained from knowing the relation by weight of roots and tops. In 1900 and 1901 carefully selected beets from all the plats were weighed before and after trimming. The results of these weighings are given in Table XX.

It does not appear from the above data that stable manure induced an excessive growth of leaves as compared with commercial manures.

It is fair to inquire if, in the nature of things, there are good reasons for expecting results different from those detailed here. Why should plant food derived from stable manure cause growth unlike that sustained by chemical manures? While we cannot enter into all the secrets of the life of the plant, such a

specific difference does not appear to be rational. It does not appear in the experiments here recorded that the yield of beets was greatly larger with 40,000 to 80,000 lbs. of stable manure per acre than with 1000 lbs. of commercial fertilizer. It seems extremely probable that if a fresh application of stable manure ever causes the ranker vegetative growth, this result must be attributed either to the larger quantities of fertilizing ingredients which are usually supplied in comparison with chemical manures, or to the modifying influences upon the soil of its organic matter as affecting texture and water holding power. Granting that the excessive amounts of nitrogen and other elements of plant food contained in the usual application of stable manure are sometimes the cause of too rank growth, then the use of less manure will modify this effect which is undesirable with some plants. In case the better texture and greater water holding power that the manure induces, and which are so desirable conditions to secure for most soils, are the explanation of the great vigor of the plants, it would not seem wise to withhold the manure, but to control the character of the growth by regulating the quantity of manure and number of plants on a given space and by other means.

The evidence which this bulletin presents shows clearly that under the conditions involved, stable manure was freely applied to the beet land in the spring just before planting the seed without injury to the quality of the beets.

If this proves to be true in general, no time limitations are to be placed on the use of such manure, and sugar beet production will not demand of the farmer an annual expenditure of cash for commercial fertilizers because they are a necessity in this line of farming.

COMMERCIAL FERTILIZERS FOR ONIONS.*

W. H. JORDAN AND F. A. SIRRINE.

SUMMARY.

(1) Experiments in the use of different quantities of a complete fertilizer in growing onions were conducted at Florida, Orange county, N. Y., for four years on the same field and for one year on a field of another farm.

(2) The quantities of fertilizer used were 0, 500 lbs., 1000 lbs., 1500 lbs. and 2000 lbs. per acre.

(3) On the Purdy field (four years), when only 500 lbs. of fertilizer was used, the manure cost of the increase of crop was 16.6 cts. per barrel; with 1000 lbs., 79.3 cts.; with 1500 lbs., 80.4 cts., and with 2000 lbs., 227.8 cts.

(4) The profit from using the fertilizer came mostly from the first 500 lbs. applied, averaging $35.84 per acre. With onions at $1.25 per barrel the profit was slightly larger (about $3 per acre) with both the 1000 lbs. and 1500 lbs. of fertilizer per acre; but 2000 lbs. was used at a loss.

(5) On the Mars field one experiment was conducted which showed no increase of yield from applying commercial fertilizer even in the larger quantities.

(6) The results of these experiments show clearly that the crops were limited more by other conditions than by the extent of the plant-food supply. With the best conditions of season and water supply the smallest amount of fertilizer supported the maximum crop.

*A reprint of Bulletin No. 206.

(7) Considering the varying market price of onions from one year to another and the various vicissitudes to which the crop is subjected, the use of the larger quantities of fertilizer (above 500 lbs.) was attended by danger of financial loss.

GENERAL CONDITIONS.

Experiments and investigations were begun by the Station in the Second Judicial Department of New York in the year 1894.

One of the conditions of practice prevalent in that portion of the State, especially with the market gardeners and potato and onion growers, was the excessive use of commercial fertilizers. The application of one ton or more per acre of a high grade, complete fertilizer was frequently observed.

Reasoning from general facts, it did not seem clear that such a large expenditure for commercial plant-food was justified from the standpoint of profit. In order to determine the correctness of this view, field experiments with fertilizers on potatoes were begun on Long Island in 1895, which were continued until 1900, during the last four years of which time observations were made on four farms located at different points in potato growing districts. The general outcome of these experiments was to show that, so far as profit from the potato crops was concerned, the use of 1000 lbs. of fertilizer per acre was more profitable than the use of 500 lbs., 1500 lbs. or 2000 lbs.

In 1898 similar observations were begun at Florida, Orange County, on the use of commercial fertilizers in growing onions. These have been continued each year since, the experiment of 1901 being regarded as concluding the series.

THE EXPERIMENTS.

PLAN.

In these experiments, conducted for four years on one farm (Purdy field) and for one year on another (Mars field), approximately one acre of land was utilized in each locality. This acre

was divided into ten plats, which were treated in accordance with the diagram shown below.

On the field where the experiment was continued for four years, each plat received the treatment as indicated each year of the entire time, with the exception noted under "Fertilizers used."

ARRANGEMENTS OF PLATS IN ONION FERTILIZER EXPERIMENTS.

1. No fertilizer.
2. 500 lbs. fertilizer per acre.
3. 1000 lbs. fertilizer per acre.
4. 1500 lbs. fertilizer per acre.
5. 2000 lbs. fertilizer per acre.
6. No fertilizer.
7. 500 lbs. fertilizer per acre.
8. 1000 lbs. fertilizer per acre.
9. 1500 lbs. fertilizer per acre.
10. 2000 lbs. fertilizer per acre.

FERTILIZERS USED.

The fertilizer was applied annually. For three years it was compounded in accordance with the formula for some time so popular with Long Island farmers, viz.: four per ct. nitrogen, eight per ct. phosphoric acid and ten per ct. potash. In 1901 the potash was changed to five per ct.

Crimson clover was sown on the Purdy field in August of 1900, which grew to a height of from four to six inches and was plowed under the very last of November. With this exception the fertilizer was the only means employed of adding fertility to the land, other than the usual cultivation. In 1901 no fertilizer was applied to plats 6 to 10 of the Purdy field.

LOCATION AND CONDITIONS OF THE EXPERIMENTS.

The location of the experiments was at Florida, Orange county, N. Y., a region where onion growing is an important industry. The soil is the kind so highly regarded by onion growers, being black, peaty and friable, with a water table about two feet below the surface, except in the time of a severe drought. Such soil appears to allow the continuous production of the same crop without the appearance of the unfavorable conditions which

follow with most soils where a rotation of crops is not practiced. During the course of the experiment insect and fungus troubles and excess of water caused more or less damage, the instances of which will be mentioned in the proper connections.

As stated, two fields were used, the Purdy field for four years and the Mars field for one year. In 1897 the former field produced a crop of onions, receiving a small application of commercial fertilizer. Previous to 1897 the crops had been grass, corn and potatoes. The Mars field had been generously manured in previous years.

NOTES.

In the conduct of these experiments approved methods of culture were followed at the hands of experienced onion growers. The fertilizer was sown broadcast before the drilling of the seed. The planting generally occurred late in April and the harvesting of the crop during the last half of August.

Unfavorable conditions prevailed to some extent every year of the experiments.

In 1898 Plat 10 of the Purdy field was flooded for a short time soon after the young plants made their appearance. Again in 1900 Plats 7, 8, 9 and 10 were partially flooded on two occasions, but this occurred late in August, not long before the crop was gathered, and as the onions which had rotted were weighed, the figures given show the approximate yield. The crops suffered more or less every year from smut, mildew and the maggot, but the plats appear not to have been injured to a sufficiently unlike extent to seriously impair the accuracy of the work in measuring the yield.

In 1900 and 1901 a mixture of sulphur and lime in the proportion of 2 to 1 by weight was sown with the seed at the rate of 150 lbs. per acre. This was sown as a preventive of smut.

Several tables follow showing the plat yield, the acreage yield calculated both in pounds and bushels and the outcome of the experiments considered from a financial point of view.

TABLE I.—YIELD OF ONIONS ON PURDY FIELD FOR FOUR YEARS, 1898–1901, BY PLATS.

Plat No.	Quantity of fertilizer per acre.	Yield per plats.[1] 1898. Lbs.	1899. Lbs.	1900. Lbs.	1901. Lbs.	Average. Lbs.
1	None	494	823	1704½	605	906
2	500 lbs.................	681½	1045½	2704	1257	1422
3	1000 lbs.................	702½	1148	2813½	1425	1522
4	1500 lbs.................	831½	1416	2736	1423	1601
5	2000 lbs.................	821	1382½	2698½	1499	1600
6	None	602	858	2118	923[2]	1125
7	500 lbs.................	693	1108	2665	1117[2]	1396
8	1000 lbs.................	721	1259½	2636	1218[2]	1458
9	1500 lbs.................	835	1341½	2588½	1398[2]	1541
10	2000 lbs.................	814½	1298	2540	1371[2]	1599[3]

[1] Size of Plats 1 to 9, .0794 acre; Plat 10, .0843 acre.
[2] Plats 6 to 10 received no fertilizer in 1901.
[3] Calculated to yield for .0794 acre.

TABLE II.—ACRE YIELD OF PURDY FIELD SHOWING INCREASE FROM FERTILIZERS.

Plat No.	Quantity of fertilizer per acre.	Average yield per acre for four years. Pounds.	Barrels.[1]	Increase over no fertilizer. Bbls.	Increase for each addition of 500 lbs. fertilizer. Bbls.
1	None	11,415	76.1[2]		
2	500 lbs...........	17,917	119.4	34.1	34.1
3	1000 lbs...........	19.177	127.8	42.5	8.4
4	1500 lbs...........	20.173	134.5	49.2	6.7
5	2000 lbs...........	20.160	134.4	49.1	0
6	None	14.175	94.5[2]		
7	500 lbs...........	17,590	117.3	32.	32.
8	1000 lbs...........	18,371	122.5	37.2	5.2
9	1500 lbs...........	19,417	129.4	44.1	6.9
10	2000 lbs...........	20,147	134.3	49.	4.9

[1] Barrel, 150 lbs.
[2] Average Plats 1 and 6, 85.3 bbls., taken as yield with no fertilizer.

TABLE III.—AVERAGE YEARLY PROFITS PER ACRE FROM USE OF FERTILIZERS ON PURDY FIELD.

Plat No.	Quantity of fertilizer used per acre.	Cost fertilizer per acre.	Value increase of crop.	Profit from fertilizer.	Profit for each addition of 500 lbs. fertilizer.
2	500 lbs..........	$6.25	$42.62	$36.37	$36.37
3	1000 lbs.........	12.50	53.12	40.62	4.25
4	1500 lbs.........	18.75	61.50	42.75	2.13
5	2000 lbs.........	25.00	61.37	36.37	—6.38
7	500 lbs..........	4.69	40.00	35.31	35.31
8	1000 lbs.........	9.37	46.50	37.13	1.82
9	1500 lbs.........	14.06	55.12	41.06	3.93
10	2000 lbs.........	18.75	61.25	42.50	1.44

AVERAGES FOR PAIRS OF PLATS.

Plat No.	Quantity of fertilizer used per acre.	Cost fertilizer per acre.	Value increase of crop.	Profit from fertilizer.	Profit for each addition of 500 lbs. fertilizer.
2 and 7	500 lbs..........	$5.47	$41.31	$35.84	$35.84
3 and 8	1000 lbs.........	10.94	49.81	38.87	3.03
4 and 9	1500 lbs.........	16.41	58.31	41.90	3.03
5 and 10	2000 lbs.........	21.87	61.31	39.44	—2.46

NOTE.—Fertilizer reckoned at $25 per ton and onions at $1.25 per barrel.
No fertilizer on Plats 6 to 10 in 1901.

TABLE IV.—FERTILIZER COST OF INCREASED YIELD OF ONIONS FROM USE OF FERTILIZERS.

Quantity fertilizer per acre.	Acre cost of fertilizer.	Average total increase of yield.	Average increase yield for each addition 500 lbs. fertilizer.	Fertilizer cost each bbl. increase onions.	Fertilizer cost per bbl. of increase from each addition 500 lbs. fertilizer.
		Bbls.	*Bbls.*	*Cents.*	*Cents.*
500 lbs.......	$5.47	33	33	16.6	16.6
1000 lbs.......	10.94	39.9	6.9	27.4	79.3
1500 lbs.......	16.41	46.7	6.8	35.1	80.4
2000 lbs.......	21.87	49.1	2.4	44.5	227.8

TABLE V.—YIELD OF ONIONS ON MARS FIELD, ONE YEAR, 1900.

Plat No.	Quantity of fertilizer per acre.	Yield per plat.	Yield per acre.	Yield per acre.	Excess yield from fertilizer.
		Lbs.	*Lbs.*	*Bbls.*	
1	None	2946.5	29,465	196.4	
2	500 lbs...........	2947	29,470	196.5	
3	1000 lbs..........	3060.5	30,605	204	
4	1500 lbs..........	3117	31,170	207.8	
5	2000 lbs..........	3051.5	.30,515	203.4	
6	None	2866.5	28,665	191.1	
7	500 lbs...........	3047.5	30,475	203.2	
8	1000 lbs..........	2775.5	27,755	185	
9	1500 lbs..........	2517	24,918	166.1	
10	2000 lbs..........	2729	25,925	172.8	

SUMMARY.

		Bbls.	Bbls.
1 and 6	None, average......................	193.7	
2 and 7	500 lbs., average....................	199.8	6.1
3 and 8	1000 lbs., average..................	194.5	.8
4 and 9	1500 lbs., average..................	186.9	—6.8
5 and 10	2000 lbs., average..................	188.1	—5.6

RESULTS.

See Summary, p. 247.

In discussing the results herewith presented we should keep in mind the limitations of field experiments as to accuracy. If an experimental field could be selected having an entirely uniform

productive capacity in every part and untoward conditions such as fungi and injurious insects were to affect one part no more than another, then we could measure with great accuracy the relative influence of different fertilizers or different quantities of the same fertilizer. Such desirable conditions as these are not to be found. Only approximate accuracy is reached in field experiments, even under the most favorable circumstances; and for this reason the accompanying figures should not be taken as representing fixed or absolute relations. The experiments convey lessons, however, which appear to the writer to be plain.

In the first place it is entirely clear that the limit of production as determined by season and other conditions outside of the supply of food was nearly reached in the Purdy field with the first 500 lbs. of fertilizer applied. This is equivalent to stating that the profits were mostly realized from the first 500 lbs. of fertilizer, the manure cost of the gain in yield being only 16.6 cents per barrel. While with the increasing quantities of fertilizer used there was on the average a corresponding increase of crop, this greater production but very little more than paid for any application of fertilizer above 500 lbs. The data show that the additional yield of onions resulting from each 500 lbs. increase of fertilizer above the first 500 lbs. had a fertilizer cost of $0.79 to $2.28 per barrel. The profits of such manuring are uncertain, depending upon market conditions.

It is to be noticed, moreover, that the added growth due to the first 500 lbs. of fertilizer was not uniform in the different years. In 1900 conditions were favorable for an onion crop, a fairly large yield being secured, and the highest returns of any year were obtained from the commercial plant-food added to the soil. The year 1898 gave the smallest crop of any of the four. Comparing the effect of the fertilizers in these two years, we see that 500 lbs. of fertilizer caused an increase in 1900 of 64.6 bbls. of onions per acre and in 1898 only 11.7 bbls. It should be noted that in 1898 the yield, though small, was progressive with the increase of fertilizer, while in 1900 the yield with 500 lbs. of fertilizer was as large as with the heavier manuring. All this

emphasizes the truth that the supply of plant-food is only one factor of crop production. Farmers often remark that "fertilizers are of little use in a dry year," which is one way of saying that in order for any manure to exercise its maximum influence, other conditions such as temperature, soil texture and water supply must be favorable. It is evident, then, that considering the varying price of the marketable product, the close margin of profit from heavy manuring with fertilizers even with fairly good prices for the crop product, and the vicissitudes of the crop due to the limitations of season, the onion grower runs great risk of diminished profits when he uses 1500 and 2000 lbs. of commercial fertilizer per acre. It should be remembered by growers of all crops that the largest yields may be the least profitable under certain conditions.

It may be suggested that the consideration merely of the gross weight of onions produced does not fairly represent the full relative influence of the several quantities of fertilizer, because the quality of the crop may be better with the heavier manuring. Data were secured from the experiment of 1901, the fourth year, which bear on this point. Attention is called to the figures of the next table.

Table VI.—Quality of Onions, Crop of 1901.

Plat.	Quantity of fertilizer.	Yield graded onions.	Yield pickle onions.	Percentage of pickle onions.
		Lbs.	*Lbs.*	*Per ct.*
1	None	526	79	13
2	500 lbs.	1218	38	3
3	1000 lbs.	1398	27	1.9
4	1500 lbs.	1379	44	3.1
5	2000 lbs.	1434	65	4.3

The proportion of small onions appears to be less where fertilizer was applied than where it was not, but not less with the heaviest manuring than with the lightest.

In 1898 it was noticed that the onions where no fertilizer was applied weighed less per barrel than those from the manured plats and should be graded mostly as scullions. The barrel weight seemed to be somewhat more where 1500 and 2000 lbs. of fer-

tilizer were applied per acre than where only 500 and 1000 lbs. were used.

Again, the question of the after effect of heavy fertilizing with purchased plant-food may well be introduced at this point. The experiments now considered furnish some evidence on this point. In 1901 no fertilizer was applied to Plats 6 to 10 of the Purdy field, crimson clover being turned under in the fall. An influence from fertilizers used in the three previous years is clearly indicated, as the yield from Plats 7 to 10 was considerably larger than on the check plat (No. 6) and nearly as large as on Plats 2 to 5, which received the usual quantities of fertilizer. The after effect of a chemical manure should be considered, therefore. Here we are again reminded that conditions other than the supply of the compounds needed for growth limited the crop.

The experiment on the Mars field should not pass unnoticed. The experiment was conducted in 1900 when a fairly large crop was secured, ranging from 188 to 199.8 bbls. of onions with the different quantities of fertilizer. The most noteworthy fact shown in this experiment is that the fertilizer, even in large quantities, failed to increase the crop. The average yield on the check plats was 193.7 bbls. and on the manured plats, 192.3 bbls.

The comment of Mr. Sirrine, in immediate charge of the experiment, was that the owner of the land "had used stable manure and fertilizers in such quantities during previous years that there was little need of fertilizer the present year." Certainly an increase of available plant-food had no effect on the growth of the crop. It is suspected that this instance illustrates a mistake in practice that is very frequently committed by farmers who follow intensive farming, viz.: the use of manure on soil already sufficiently charged with the available materials necessary to plant growth.

REPORT

OF THE

Department of Entomology.

V. H. Lowe, *Entomologist.*

F. A. Sirrine, *Entomologist.*[1]

P. J. Parrott, *Assistant Entomologist.*

Table of Contents.

[1] At Second Judicial Department Branch Station.

SAN JOSÉ SCALE INVESTIGATIONS. III.*

V. H. LOWE AND P. J. PARROTT.

SUMMARY.

Spraying experiments with emulsions of crude petroleum and water gave the following results:

Winter applications of the emulsion containing 25 per ct. of petroleum and higher percentages seriously injured or killed peach trees. European plum trees and apple trees were uninjured except by 40 per ct. and stronger emulsions. Cherry and pear trees were not injured by either the emulsified or undiluted petroleum.

Spring applications of the emulsion of the same percentages resulted in serious injury to European plum trees by the undiluted petroleum, slight injury by the 60 per ct., while the 40 per ct. was harmless except to a number of old plum trees which had been somewhat weakened by disease. Peach trees were seriously injured by the 40 per ct. and stronger emulsions. Young cherry and pear trees were uninjured by the diluted and undiluted petroleum.

Experiments to determine the percentage of petroleum required to kill the hibernating scales resulted in a failure with the 25 per ct., while the 40 per ct. and higher percentages killed the scales in both the winter and spring series. But, as indicated above, 40 per ct. emulsion should be used only in spring a short time before the buds begin to swell; and not at any time upon peach trees.

Fumigation experiments with hydrocyanic acid gas at strengths varying from .18 to .3 gram of cyanide per cubic foot of air space, resulted in practically no injury to apple, cherry,

*A reprint of Bulletin No. 202.

pear and plum buds. Peach buds were uninjured by the gas at a strength of .22 gram, but showed indications of slight injury at .3 gram. Experiments in the winter (December) resulted in a failure to kill the scales with the gas at a strength less than .3 gram, while the spring experiments (early June) resulted in killing the scales with the gas at .18 gram.

I. SPRAYING EXPERIMENTS WITH CRUDE PETROLEUM.

INTRODUCTORY.

Crude petroleum is one of the recent additions to the list of insecticides. It was first brought into prominence in this capacity by Dr. J. B. Smith[1] of the New Jersey Agricultural Experiment Station. During his experiments nearly 4,000 fruit trees were treated, including the ordinary orchard fruits with the exception of cherry. The petroleum was used pure and mixed with 60 and 75 per ct. of water. The trees were treated at various times from January to March. Summarizing these experiments Dr. Smith states, in the bulletin previously referred to, page 20: "Not a single case of injury to any tree treated in winter has been observed; on the contrary in a number of cases the oil seems to have acted as a stimulant, and the sprayed trees have shown greater vigor and better foliage than those untreated." From his experiments Dr. Smith also draws the conclusion (page 21) that crude petroleum "is harmless to the most tender varieties and on the youngest trees."

These experiments were followed in 1900 by a somewhat less extensive series in West Virginia. In summing up the results, Prof. L. C. Corbett, under whose direction the experiments were made, states[2] that apple, peach and plum trees sprayed May 16 seemed to thrive under a treatment of 20 per ct. crude petroleum. Also that none of the fruit or leaf buds were injured and that although the trees were infested before treatment no live scales were found on the treated trees. Experiments with undiluted crude petroleum applied April 3 to badly infested Japanese

[1] N. J. Agr. Exp. Sta. Bul. 138.
[2] W. Va. Agr. Exp. Sta. Bul. 70, p. 373.

plum trees and in February to other varieties of fruit trees are considered as showing that undiluted petroleum does not injure fruit trees, although it may remain upon them for six months; also that it kills the scales when coming in contact with them and that it has given the most promising results of any of the insecticides that had come into use at that time.

The experiments in this State by the State Entomologist, Dr. E. P. Felt, furnished one of the first published records of results with the insecticide in the north.[3] A number of fruit and ornamental trees were included in these experiments. The former consisted principally of wild cherry, peach, plum, pear, quince and crab apple. Twenty and twenty-five per ct. emulsions of crude petroleum and water were used as well as undiluted petroleum. All of the trees were sprayed in April. From these experiments Dr. Felt concludes that "the trees appeared to be uninjured by the insecticide[4] though possibly a little retarded, while a large proportion of the scales are killed and on some trees it would appear as though every one had been annihilated;" also that the results with the 25 per ct. emulsion were not enough better to warrant the use of the higher percentage of oil and that owing to the serious injury to the trees treated with the undiluted petroleum its use cannot be recommended.

THE PRESENT STATUS OF CRUDE PETROLEUM AS AN INSECTICIDE.

The above review, which includes the principal experiments with crude petroleum yet published, brings out some points in which the results as reported do not agree. It will be noticed that Dr. Smith concludes that "straight" crude petroleum, of the right character and specific gravity, if properly handled, is harmless to the most tender varieties of fruit trees even when applied undiluted, and that it may be depended upon to kill the dormant scales when used undiluted or diluted with 60 or 75 per ct. of water.

While these experiments were supported in the main by those of Prof. Corbett, the experiments by Dr. Felt, although agreeing

[3] New York State Museum Bul. 36 (Vol. 7).

[4] Refers to the 20 per ct. emulsion.

with the Virginia results in that the 20 per ct. mixture killed the scales, gave very different results with undiluted petroleum. In this case, although the petroleum was of the required character, testing 43°, it seriously injured or killed all the trees to which it was applied.

From the above review and summary it appears that the exact effect of crude petroleum of the proper standard upon both scales and trees is not yet fully determined; hence further investigation is desirable.

OBJECTS OF THE EXPERIMENTS.

The experiments with crude petroleum reported in this bulletin were undertaken principally with a view to adding further data as to its effect upon both scales and trees. Conflicting results with this insecticide in the hands of Western New York orchardists have also made a series of experiments in this section of the State desirable.

CONDITION AND CLASSIFICATION.

The experiments were conducted in a number of different orchards, all of them in western New York. In each case the condition of the trees was carefully noted.

The crude petroleum used was purchased of the Standard Oil Company. It was dark green in color and had a specific gravity of 44°.

An emulsifying pump of the type that emulsifies the oil and water at the nozzles was used in all of the experiments. The spray was very fine and the emulsion thus made was excellent, the oil being so thoroughly broken up that it did not wholly separate from the water in the 1,000 cc. graduate in which the tests were made for over two days.

To avoid error in the amount of oil applied the pump was frequently tested. These tests showed only very slight variations in the percentages.

Much pains was also taken to make the applications thorough and uniform. The spray was directed upon the tree until it

began to drip slightly. By so doing all of the emulsion that would adhere was applied to each tree. It is apparent that if less were applied it would be very difficult to tell whether the work had been thorough or not. On the other hand prolonged spraying and consequent over drenching would be merely a waste of material and would have practically no effect upon the quantity of petroleum that finally clings to the tree because the excess of emulsion does not adhere to it. Also if the machine emulsifies the oil and water as thoroughly as in our own experience there will be no danger from free oil as the excess of emulsion will drain off before separation can take place. Hence a tree sprayed to a moderate excess with an emulsion containing say 25 per ct. of petroleum would finally retain no more petroleum than if sprayed merely to the dripping point. If, therefore, the spray is directed upon each tree until its full capacity to hold the emulsion is reached, that is until it begins to drip, an amount of oil in proportion to the percentage indicated is practically maintained. However, it is to be noted that in the case of unusually rough or cracked bark or open wounds that would hold the emulsion the accumulation of oil may cause injury. It is also possible that, in case of over drenching, the oil that would soak into the ground might cause injury to the roots.

CHARACTER OF CRUDE PETROLEUM.

Crude petroleum is an oily, inflammable liquid varying in color from very dark brown to greenish tints. By refining it yields a number of valuable products including paraffin, lubricating and illuminating oils and a series of highly volatile oils. It is the heavier oils that make it especially valuable as an insecticide. Crude petroleum varies in appearance and composition according to the locality from which it was taken. The eastern oils are said to vary greatly from the western and most foreign oils, the former having a paraffin and the latter an asphalt base. The true indication of the safety of petroleum as an insecticide evidently depends upon its specific gravity; as it has been found that petroleum having a specific gravity of 43° or

above (Baumé oil scale at a temperature of 60° F.) is less likely to injure the trees than petroleum of a lower specific gravity, although oils of a lower specific gravity have been successfully used in some instances, notably in Canada.

REASON FOR EMULSIFYING THE PETROLEUM.

A very thin film of petroleum covering the entire tree is all that is required to kill the scale. Theoretically, by using a very fine nozzle, the undiluted petroleum might be applied in a thin film but in practice it has been found very difficult if not impossible to make the treatment thorough without applying a dangerous and wasteful excess. For this reason emulsifying the petroleum with water is desirable as the tree can then be thoroughly wet without applying an excess of oil.

SERIES I. EXPERIMENTS TO DETERMINE THE EFFECTS OF CRUDE PETROLEUM UPON SOUND TREES.

ORCHARD I: PLUMS, PEARS AND CHERRIES.

This orchard consists of 152 plum, 13 pear and 13 cherry trees. The plums consist of Monarch, Reine Claude and Quackenboss varieties; the pears Bartlett and the cherries Montmorency. The Reine Claudes, which include about one-third of the plums, are old trees that have been weakened by disease and decay but usually bear a small crop of fruit. The Monarch and Quackenboss trees are sound, especially the latter which are unusually vigorous. The orchard has been kept continually under high cultivation.

Summaries of treatments and results in Orchard I are given in Tables I, II and III. The checks, which are not given in the tables, consisted of a large number of trees of the same varieties in adjoining rows. In every case they showed no indications of injury during the winter.

Weather during tests in Table I.—Winter treatment. Trees sprayed Dec. 22 to 24. Average temperature of the three days 39°, cloudy. Weather during the week following usually cloudy with average temperature of 29°.

Table I.—Winter Spraying in Orchard I.

Trees.			Strength of petroleum.	Results.
Kind.	Number treated.	Age and description.	Per ct.	
Plum:				
Reine Claude.	7	Old, weakened by disease.	25	Two slightly injured, remainder uninjured.
Monarch	4	Full bearing, sound..	25	No injury.
Quackenboss .	6	Full bearing, sound and unusually vigorous.	25	No injury.
Reine Claude.	8	Old, weakened by disease.	40	Four seriously injured, remainder slightly.
Monarch	5	Full bearing, sound..	40	All slightly injured.
Quackenboss .	6	Full bearing, sound and unusually vigorous.	40	All slightly injured.
Reine Claude.	8	Old, weakened by disease.	60	Five dead and three seriously injured.
Monarch	6	Full bearing, sound..	60	All slightly injured.
Quackenboss .	6	Full bearing, sound and unusually vigorous.	60	All slightly injured.
Reine Claude.	6	Old, weakened by disease.	100	All dead.
Monarch	7	Full bearing, sound..	100	Three dead, remainder seriously injured.
Quackenboss .	6	Full bearing, sound and unusually vigorous.	100	All seriously injured.
Pear:				
Bartlett	3	One year planted, vigorous.	25	No injury.
Bartlett	3	One year planted, vigorous.	40	No injury.
Bartlett	1	One year planted, vigorous.	60	No injury.
Bartlett	1	One year planted, vigorous.	100	No injury.
Cherry:				
Montmorency.	2	One year planted, vigorous.	25	No injury.
Montmorency.	2	One year planted, vigorous.	40	No injury.
Montmorency.	3	One year planted, vigorous.	60	No injury.
Montmorency.	2	One year planted, vigorous.	100	No injury.

Weather during tests in Table II.—Spring treatment. Trees sprayed April 18. Temperature 52°, cloudy. Weather during the week following usually cloudy with average temperature of 48°.

TABLE II.—SPRING SPRAYING IN ORCHARD I.

Trees. Kind.	Number treated.	Age and description.	Strength of petroleum. Per ct.	Results.
PLUM:				
Reine Claude.	6	Old but usually bear a small crop.	25	Two dead, three seriously injured.
Monarch	5	Full bearing, sound..	25	Uninjured.
Quackenboss..	3	Full bearing, unusually vigorous.	25	Uninjured.
Reine Claude.	4	Old but usually bear a small crop.	40	Three dead, one seriously injured.
Monarch	5	Full bearing, sound..	40	Two slightly injured, remainder uninjured.
Quackenboss..	3	Full bearing, unusually vigorous.	40	Uninjured.
Reine Claude.	4	Old but usually bear a small crop.	60	All dead.
Monarch	6	Full bearing, sound..	60	Two dead, remainder seriously injured.
Quackenboss..	3	Full bearing, unusually vigorous.	60	Slightly injured.
PEAR:				
Bartlett	1	One year planted, vigorous.	25	Uninjured.
Bartlett	1	One year planted, vigorous.	60	Uninjured.
CHERRY:				
Montmorency.	2	One year planted, vigorous.	40	Uninjured.
Montmorency.	1	One year planted, vigorous.	60	Uninjured.

Time of tests in Table III.—Winter and spring treatment. Trees sprayed Dec. 24 and April 18.

TABLE III.—WINTER AND SPRING SPRAYING IN ORCHARD I.

Trees. Kind.	Number treated.	Description.	Strength of petroleum. Per ct	Results.
PLUM:				
Quackenboss..	3	Full bearing, unusually vigorous.	25	Uninjured.
Reine Claude.	1	Old, but usually bear a small crop.	40	Dead.
Monarch	1	Full bearing, vigorous.	40	Dead.
Monarch	3	Full bearing, vigorous.	60	Dead.
Reine Claude.	2	Old, but usually bears small crop.	100	Dead.
Monarch	1	Full bearing, vigorous.	100	Dead.
PEAR:				
Bartlett	1	One year planted, vigorous.	40	Seriously injured.
Bartlett	1	One year planted, vigorous.	60	Dead.
CHERRY:				
Montmorency.	3	One year planted....	40	All seriously injured.

SUMMARY FOR ORCHARD I.

In the winter treatment (Table I) none of the healthy plum trees showed evidence of injury by the 25 per ct. emulsion but all were injured and some killed by the 40 per ct. and above. In all cases the old trees (Reine Claude) were more sensitive to the treatment than the others, some of them being injured by the weakest emulsion, half of those treated with the 4 per ct. seriously injured and all killed or seriously injured by the stronger emulsion and the undiluted petroleum. The younger trees, Monarch and Quackenboss, especially the latter, stood the treatment better, being uninjured by the 25 per ct. and only slightly by the 40 per ct. emulsion. The pears and cherries were uninjured.

The spring treatment (Table II) shows even more serions injury to the Reine Claudes than the winter treatment but the other varieties consisting of younger trees were less affected being uninjured by the 40 per ct. and only slightly by the 60 per ct. emulsion. Both the pears and cherries were uninjured by the highest percentage of petroleum (60 per ct.) used in this series.

As was to be expected the winter and spring treatments combined (Table III) caused more serious injury than either of the single applications. The Quackenboss was the only variety treated with 25 per ct. emulsion and the trees were not injured. Reine Claudes and Monarchs were treated with the higher percentages with the result that every tree was killed.

From these results it appears that the spring treatment was slightly less injurious than the winter treatment while the two combined proved fatal except with the 25 per ct. emulsion. The 40 per ct. and stronger emulsions caused so much injury to the plum trees as to indicate that they are dangerous. The only exception was the Quackenboss trees which were uninjured by the 40 per ct. although unable to withstand the higher percentages. The lack of injury to the pear and cherry trees even by the undiluted petroleum indicates strongly that these trees are much less susceptible to crude petroleum than the plums.

SERIES II. SPRAYING EXPERIMENTS TO DETERMINE THE EFFECTS OF CRUDE PETROLEUM UPON HIBERNATING SCALES.

The experiments of this series were conducted in Orchards II, III and IV.

ORCHARD II: PEARS.

The experiments of Series II were begun in this orchard which consists of 101 pear trees, nearly all of which are standard Bartletts. The trees were planted about six years ago and except for the first two years have received but little care. During the past four years the orchard has been in sod. It is quite probable that some of the trees were infested when planted but the scale was not noticed until the spring of 1898. When the experiments were begun in 1900 most of the trees were extensively infested, many being encrusted on the trunk and larger limbs. Before the experiments were begun they were carefully trimmed and the orchard was divided into two sections. The first, containing 54 trees, was treated with crude petroleum, and the second, containing all of the remaining trees, except a few reserved for checks, with hydrocyanic acid gas as noted in a subsequent section of this bulletin.

Summaries of the spraying experiments and results in this orchard are given in Tables IV, V, VI and VII. The check trees are not recorded in the tables. In every case the scales had multiplied rapidly. The live ones were abundant upon both the new and old growth.

Weather during tests in Table IV.—Fall treatment. Trees sprayed Oct. 23. Temperature 64°, cloudy. Weather during the week following usually bright, with average temperature of 59°.

TABLE IV.—FALL SPRAYING IN ORCHARD II.

Trees.			Strength of petroleum.	
Kind.	Number treated.	Degree of infestation.	Per ct.	Results.
PEAR:				
Bartlett	2	Both extensively[2] infested.	25	Scales not affected, trees uninjured.
Bartlett	2	1 Extensively infested. 1 Moderately infested.	40	Scales dead, trees uninjured.

[2] "Extensively infested" as used in this and other tables means that the trees were encrusted on parts of the trunk and some of the larger limbs. Moderately and slightly infested mean to a less degree.

Time of tests in Table V.—Winter treatment. Trees sprayed Dec. 24.

TABLE V.—WINTER SPRAYING IN ORCHARD II.

Trees.			Strength of petroleum.	
Kind.	Number treated.	Degree of infestation.	Per ct.	Results.
PEAR:				
Bartlett	4	1 Extensively, 1 mildly and 2 slightly infested.	25	Scales not affected. Trees uninjured.
Bartlett	4	2 Extensively and 2 slightly infested.	40	Scales dead.[3] Trees uninjured.
Bartlett	4	3 Extensively infested (2 nearly dead), 1 moderately infested.	60	Scales dead.[3] Trees uninjured.
Bartlett	4	3 Extensively infested (2 nearly dead), 1 moderately infested.	100	Scales dead. The two trees most seriously infested were killed the others slightly injured.

[3] On some of the trees sprayed with the high percentages of crude petroleum an occasional live scale was found, but as they were always upon some small twig that might easily have escaped thorough treatment they were not considered as affecting the results.

Time of tests in Table VI.—Spring treatment. Trees sprayed April 18.

TABLE VI.—SPRING SPRAYING IN ORCHARD II.

Trees. Kind.	Trees. Number treated.	Trees. Degree of infestation.	Strength of petroleum. Per ct.	Results.
PEAR:				
Bartlett	4	2 Extensively and 2 mildly infested.	25	Scales not affected. Trees uninjured.
Bartlett	4	2 Extensively and 2 mildly infested.	40	Scales dead. Trees uninjured.
Bartlett	4	3 Extensively and 1 mildly infested.	60	Scales dead. Trees uninjured.
Bartlett	4	All mildly infested...	100	Scales dead. Trees uninjured.

Weather during tests in Table VII.—Winter and spring treatment. Trees sprayed Dec. 8 and April 18. Dec. 8 temperature 29°, cloudy. Weather during the week following alternating cloudy and fair with average temperature of 22°.

TABLE VII.—WINTER AND SPRING SPRAYING IN ORCHARD II.

Trees. Kind.	Trees. Number treated.	Trees. Degree of infestation.	Strength of petroleum. Per ct.	Results.
PEAR:				
Bartlett	3	1 Extensively and 2 mildly infested.	25	Scales show slight effect of treatment. Trees uninjured.
Bartlett	4	2 Moderately and 2 slightly infested.	40	Scales dead. Trees uninjured.
Bartlett	4	2 Moderately and 2 slightly infested.	60	Scales dead, 1 tree dead, 1 nearly dead and 2 seriously injured.
Bartlett	4	1 Extensively and 3 moderately infested.	100	Scales dead, 3 trees dead, 1 nearly dead

SUMMARY FOR ORCHARD II.

The experiments in this orchard indicate that the 25 per ct. emulsion cannot be depended upon to kill the dormant scales, while the 40 per ct. emulsion gives satisfactory results. The power of the pear tree to resist the injurious effects of crude petroleum is also indicated. There was no apparent injury to any of the trees sprayed once, although many were much weakened by the scale, except in one case where the trees were nearly

dead at the time time of spraying. These trees were killed by the undiluted petroleum (Table V.). The trees sprayed twice (Table VII), with 60 per ct. and undiluted petroleum were killed or seriously injured in every case. But those receiving the weaker emulsions, 25 and 40 per ct., were uninjured indicating that pear trees may be sprayed twice, once during the winter and once during the early spring with a petroleum emulsion strong enough (40 per ct.) to kill the scale without being injured.

ORCHARD III: APPLES.

This orchard consists of thirty-two Baldwin apple trees in full bearing. All were infested but none sufficiently to be seriously weakened. They have been well cared for and, except for the scale, are in good condition.

The experiments were undertaken principally to ascertain whether large trees moderately infested with the scale could be satisfactorily treated with crude petroleum. The trees were too large to make thorough spraying practicable without severe pruning. They were therefore cut back severely in October and finally sprayed, with the results shown in Tables VIII and IX.

Weather during tests in Table VIII.—Winter treatment. Trees sprayed Dec. 20 to 22. Average temperature of the three days 33°.

TABLE VIII.—WINTER SPRAYING IN ORCHARD III.

Trees.			Strength of petroleum.	
Kind.	Number treated	Degree of infestation.	*Per ct.*	Results.
APPLE:				
Baldwin	8	1 Extensively, 3 moderately and 4 slightly infested.	25	Scales not affected. Trees uninjured.
Baldwin	8	1 Extensively, 2 moderately and 5 slightly infested.	40	Scales dead, except on some of the small branches where many live ones were found. 5 trees dead, remainder seriously injured.

Weather during tests in Table IX.—Spring treatment. Trees sprayed April 19. Temperature 34°, cloudy with slight rain. Weather during the week following cloudy with frequent showers. Average temperature 48°.

TABLE IX.—SPRING SPRAYING IN ORCHARD III.

Trees.			Strength of petroleum.	Results.
Kind.	Number treated.	Degree of infestation.	*Per ct.*	
APPLE:				
Baldwin	8	2 Extensively and 6 moderately infested.	25	Scales not affected. Trees uninjured.
Baldwin	8	1 Extensively and 3 moderately infested.	40	Scales dead, except on some of the small branches where many live ones were found. Trees uninjured.

SUMMARY FOR ORCHARD III.

The results in this orchard show only partial success for the treatment. As with the other experiments the 25 per ct. emulsion had no noticeable effect on the insect. The lack of thorough work with the 40 per ct. emulsion appeared to be due to the difficulty of reaching every limb and twig on large trees. This seems evident because nearly all of the scales were dead, the live ones being found only on a few small branches that might easily have escaped thorough treatment. The serious injury to the eight trees sprayed during the winter with the 40 per ct. mixture was unexpected. As apples are not considered especially sensitive to treatment with crude petroleum and similar insecticides and as the other apple trees included in the experiments were not seriously injured by similar treatment it seems probable that some other factor besides the petroleum must have had an important influence. The apple trees that were uninjured by the winter treatment of 40 per ct. emulsion were not trimmed just before being sprayed as was the case with the injured trees, and as the pruning was unusually severe it may have weakened the trees sufficiently to cause them to succumb to the treatment.

ORCHARD IV: PEACH, PEAR AND APPLE TREES.

This small orchard consists of ten peach, pear and apple trees just coming into bearing. The orchard has evidently received fairly good care, and until two or three years ago the trees were thrifty. Recently most of them have shown signs of weakness, probably due in part to the San José scale.

The treatment and results are summarized in Table X.

Time of tests in Table X.—Winter treatment. Trees sprayed Dec. 20 to 24.

TABLE X.—WINTER SPRAYING IN ORCHARD IV.

Trees.			Strength of petroleum.	Results.
Kind.	Number treated.	Degree of infestation.	*Per ct.*	
PEACH:				
Var. unknown.	2	Slightly infested......	25	Scales not affected. Trees slightly injured.
Var. unknown.	1	Slightly infested......	40	Scales dead. Tree seriously injured.
PEAR:				
Var. unknown.	2	Slightly infested......	40	Scales dead. Tree uninjured.
APPLE:				
Var. unknown.	5	Extensively infested..	40	Scales dead, 2 trees seriously injured, remainder uninjured.

SUMMARY FOR ORCHARD IV.

In these experiments also, the 25 per ct. emulsion did not kill the scales while the 40 per ct. was effectual. The peach trees, although no more seriously infested than the pears, were slightly injured by the 25 per ct., and seriously injured by the 40 per ct. emulsion. Two of the apple trees were injured by the 40 per ct. emulsion but not seriously.

ORCHARD V: PLUM TREES.

This orchard consists of twenty plum trees which have recently come into full bearing. All of them are extensively infested and somewhat weakened by the San José scale. As shown in the following table half were sprayed in the spring

with a resin wash and the remainder with a whitewash known as government whitewash. Both have been suggested as being effectual against the San José scale. They were made after the following formulae:

Resin Wash.

Resin	10½ pounds
Soap	21 pounds
Fish oil....................................	1¾ quarts
Water	21 gallons

Boil the resin, soap and fish oil in about one-fourth of the water until dissolved. While boiling, gradually add remainder of the water. Care should be taken not to add the cold water too fast as it has a tendency to precipitate the resin.

Government whitewash.

Slaked lime....................................	½ bushel
Salt	½ bushel
Rice	6 pounds
Glue	2 pounds
Water	10 gallons

Boil the rice with enough of the water to make a moderately thin paste. Dissolve the glue in a small amount of hot water and boil the salt and lime in what is left of the ten gallons of water until a thin whitewash is formed. Then add the rice and glue solutions to the whitewash and boil for at least half an hour.

Weather during tests in Table XI.—Spring treatment. Trees sprayed April 12. Temperature 47°, fair. Weather during the week following usually fair with average temperature of 51°.

TABLE XI.—TREATMENTS IN ORCHARD V.

Trees. Kind.	Number treated.	Degree of infestation.	Mixture used.	Results.
PLUM:				
Var. unknown.	10	3 extensively and 7 moderately infested.	Resin-lime mixture.	Scales not affected. Trees uninjured.
Var. unknown.	10	4 extensively and 6 moderately infested.	Government whitewash.	Scales not affected. Trees uninjured.

SUMMARY FOR ORCHARD V.

Although twenty infested trees were used in these experiments and unusual pains taken to make the applications thorough there were no beneficial effects apparent in either case. The scales were breeding as rapidly during the summer on the treated trees as on the checks. Although there was a week of dry weather immediately following the applications, the unfavorable results may have been due in large part to an unusually wet spring. The heavy rains washed both compounds almost entirely off before the summer was over. Further experiments with these washes seem desirable as they have not yet been sufficiently tested to prove or disprove their value.

GENERAL SUMMARY.

The experiments with crude petroleum include 321 fruit trees consisting of apples, cherries, pears, peaches and plums. The results were fairly uniform. In the experiments of Series I no injury was caused by the 25 per ct. emulsion, but in every case the 40 and higher percentages caused serious injury to the plum trees while the pear and cherry trees were practically unharmed. The younger and more vigorous plum trees were injured less than the old and weaker ones.

The experiments included in Series II show serious injury to peach trees by the 25 per ct. emulsion and equally serious injury to plum and apple trees by the 40 per ct. emulsion. In all cases of injury it is to be noted that the most serious injury was caused by the fall applications and by two applications—one in the fall and one in the spring. These results do not agree with those of Smith and Corbett previously referred to but agree in the main with those of Felt who, as previously stated, found that the undiluted petroleum caused serious injury to the treated trees.

The experiments to ascertain the percentage of petroleum in the petroleum and water emulsion required to kill the hibernating scales also gave uniform results. The 25 per ct. emulsion failed to affect the scales materially while the 40 per ct. killed

them in every instance. The failure of the 25 per ct. to kill the scales does not agree with the results of Felt and Corbett who report success with a 20 per ct. emulsion. The reason for this is not readily apparent. It is to be noted, however, that although an examination of the treated trees made in the spring may indicate that the treatment has been successful, definite and final results cannot be obtained without several examinations during the following season. This is especially true in the latitude of New York State where a large percentage of the scales die during the winter so that during the spring but few live ones can be found. But later in the season after breeding begins the real condition can be much more easily determined.

Taken as a whole the spraying experiments reported in this bulletin indicate the following:

1. Vigorous trees are probably less liable to injury by crude petroleum than weak ones.
2. Peach and plum trees are more sensitive to crude petroleum than apples, cherries, or pears.
3. There is less danger of injury if trees are sprayed in early spring than during the fall or winter.
4. The 25 per ct. emulsion of crude petroleum and water cannot be depended upon to kill the hibernating scales in the latitude of Western New York, while the 40 per ct. has proven efficient.
5. Much pains should be taken to avoid over-drenching the trees. Only enough of the emulsion should be applied to wet the bark evenly and thoroughly.

II. FUMIGATION EXPERIMENTS WITH HYDROCYANIC ACID GAS.

INTRODUCTORY.

Fumigation with hydrocyanic acid gas is now recognized as one of the best known methods of combating scale insects. The gas was first brought into prominence as an insecticide in 1886

by Mr. D. W. Coquillett who made extensive experiments in California. Although it was being extensively used in California it received but little attention in the east until in 1897 when Prof. W. G. Johnson took up the problem of successfully combating the San José scale in Maryland. After extensive experiments he decided that two-tenths gram of 98 per ct. potassium cyanide per cubic foot was sufficient for outdoor fumigation of deciduous trees when in the dormant state, that dormant nursery trees should be fumigated with .25 gram of cyanide and buds, grafts and scions with not more than .16 gram. In connection with these experiments Johnson developed better methods of handling and applying the gas than had been previously in use and called attention to its wide range of usefulness until now it is employed in green houses, graneries, mills and other buildings subject to infestation by insects.

In this State the gas is used extensively for fumigating dormant nursery trees. Until the past two years, however, but few attempts have been made to use it in the orchard and in this capacity it may still be considered in the experimental stage so far as this State is concerned.

The experiments reported in this bulletin were begun during the fall of 1900 and continued during the following winter and spring. The principal objects of the experiments were to determine the effects, if any, of the gas upon healthy buds and the strength of the gas required to kill the hibernating scales.

CONDITIONS.

The buds were fumigated in small box fumigators made especially for the purpose. For the orchard trees fumigators of the type described in Bulletin 181 were used. All of the fumigators were carefully tested and found to be gas tight. The gas was generated in the manner described in Bulletin 194, page 382. The amount of cyanide used varied from .18 gram per cubic foot of air space to .3 gram as shown in the tables.

CHARACTER OF HYDROCYANIC ACID GAS.

Hydrocyanic acid gas may be generated by bringing cyanide of potassium in contact with sulphuric acid. It is colorless, has a faint odor of almonds, and when inhaled, unless largely diluted with air, is very dangerous. Much care should therefore be used in handling it.

CLASSIFICATION.

The experiments were divided into two series. Series I included the experiments with uninfested buds and Series II the experiments with the hibernating scales.

SERIES I. EFFECT OF THE GAS UPON BUDS.

The following experiments with buds of a variety of fruits were undertaken to ascertain if possible whether bud sticks could be safely fumigated with the gas strong enough to kill the scale. The conditions were not entirely satisfactory as the treatment was somewhat delayed and the treated buds were not set in until the first week of August. This was out of season for most of the varieties. Also the treated buds were not set in until after the checks, which were budded at the proper time, and were placed about four inches above them where they were too high to be protected by the earth thrown against the trees during fall cultivation. In addition to this they were necessarily placed on the furrow sides of the trees thus endangering them to injury during cultivation. These unfavorable conditions must be in part, and probably in large part, the cause for the failure of the treated buds to set or grow, on the average, equally as well as the checks.

Table XII.—Effect of Hydrocyanic Acid Gas Upon Apple Buds.

Treatment.						Results.	Checks.			
Strength of gas.[1] *Gram.*	Duration of treatment.	Varieties.	No. buds treated.	No. buds set.	Per ct. set.	Growth.	No. buds.	No buds set.	Per ct. set.	Growth.
0.18	½ hour	Jonathan	20	18	90	Equal to checks	20	17	85	Good.
0.18	½ hour	Fall Pippin	27	21	77.8	Not quite equal to checks	27	27	100	Good.
0.18	½ hour	Oldenburg	29	25	86.2	Same as checks	29	17	58.6	Poor.
0.18	½ hour	Ben Davis	23	18	78.3	Same as checks	23	22	95.7	Good.
0.18	½ hour	Fameuse	26	25	96.2	Same as checks	30	21	70	Fair.
0.18	½ hour	Transcendent	27	20	74.1	Average about 1 foot less than checks. Foliage good.	27	26	96.3	Excellent.
0.18	½ hour	Hyslop	33	24	72.7	Average a little taller than checks	33	32	96.9	Excellent.
		Totals	185	151	81.6		189	162	85.7	
0.18	1 hour	Jonathan	25	20	80	About same as checks	25	22	88	Good.
0.18	1 hour	Fall Pippin	28	15	53.6	Not quite equal to checks	35	32	91.4	Good.
0.18	1 hour	Oldenburg	35	32	91.4	Same as checks	38	24	63.2	Poor.
0.18	1 hour	Ben Davis	39	26	66.7	Same as checks	33	24	72.7	Good.
0.18	1 hour	Fameuse	19	14	73.7	Same as checks	37	17	45.9	Fair.
0.18	1 hour	Transcendent	31	25	80.6	Average about 1 foot shorter than checks. Foliage good.	31	29	93.5	Excellent.
0.18	1 hour	Hyslop	30	28	93.3	Average a little taller than checks	33	32	96.9	Excellent.
		Totals	207	160	77.3		232	180	77.6	
0.22	½ hour	Jonathan	24	22	91.7	About same as checks	24	23	95.8	Good.
0.22	½ hour	Fall Pippin	25	20	80	Not quite equal to checks	25	22	88	Good.
0.22	½ hour	Oldenburg	27	22	81.5	Same as checks	24	23	95.8	Poor.
0.22	½ hour	Ben Davis	29	17	58.6	Same as checks	30	19	63.3	Good.
0.22	½ hour	Fameuse	17	12	70.6	Same as checks	21	17	80.9	Fair.

[1] Strength of gas is expressed by amount of potassium cyanide used for each cubic foot of space fumigated.

TABLE XII.—*Continued.*

Treatment.			Results.				Checks.			
Strength of gas [1] *Gram.*	Duration of treatment.	Varieties.	No. buds treated.	No. buds set.	Per ct. set.	Growth.	No. buds.	No. buds set.	Per ct. set.	Growth
0.22	½ hour	Transcendent	36	31	86.1	Average about 1½ feet shorter than checks. Foliage good.	36	34	94.4	Excellent.
0.22	½ hour	Hyslop	22	18	81.8	Average a little taller than checks	22	20	90.9	Excellent.
		Totals.........	180	142	78.9		182	158	86.8	
0.22	1 hour	Jonathan	26	21	80.8	About same as checks.......	26	14	53.9	Good.
0.22	1 hour	Fall Pippin........	30	20	66.7	Not quite equal to checks....	30	26	86.7	Good.
0.22	1 hour	Oldenburg	29	27	93.1	About same as checks.......	25	25	100	Poor.
0.22	1 hour	Ben Davis.........	22	21	95.5	About same as checks.......	25	24	96	Good.
0.22	1 hour	Fameuse	23	17	73.9	About same as checks.......	27	20	74.1	Fair.
0.22	1 hour	Transcendent	32	28	87.5	Average about 1 foot shorter than checks. Foliage good.	34	34	100	Excellent.
0.22	1 hour	Hyslop	30	25	83.3	About same as checks.......	30	27	90	Excellent.
		Totals	192	159	82.8		197	170	86.3	
0.30	½ hour	Jonathan	24	18	75	About same as checks.......	24	23	95.8	Good.
0.30	½ hour	Fall Pippin.........	27	16	59.3	Not quite equal to checks....	27	23	85.2	Good.
0.30	½ hour	Oldenburg	45	38	84.4	Not quite equal to checks....	43	40	93	Poor.
0.30	½ hour	Ben Davis..........	24	24	100	Not quite equal to checks....	29	28	96.6	Good.
0.30	½ hour	Fameuse	31	28	90.3	Not quite equal to checks....	35	25	71.4	Fair.
0.30	½ hour	Transcendent	19	18	94.7	Average about 1 foot less than checks	19	18	94.7	Excellent.
0.30	½ hour	Hyslop	32	29	90.6	Average about 6 inches shorter than checks. Foliage good.................	32	31	96.9	Excellent.
		Totals	202	171	84.7		209	188	89.9	

0.30	1 hour	Jonathan	25	12	48	About same as checks.......	25	21	84	Fair.
0.30	1 hour	Fall Pippin........	23	10	43.5	Not quite equal to checks....	23	23	100	Good.
0.30	1 hour	Oldenburg	32	27	84.4	About same as checks.......	34	23	67.6	Poor.
0.30	1 hour	Ben Davis.........	25	21	84	About same as checks.......	27	19	70.4	Good.
0.30	1 hour	Fameuse	22	19	86.4	About same as checks.......	25	15	60	Fair.
0.30	1 hour	Transcendent	31	29	93.5	Average about 1 foot less than checks. Foliage good.	31	30	96.8	Excellent.
0.30	1 hour	Hyslop	33	32	96.9	Average about 6 inches shorter than checks. Foliage good.................	33	29	87.9	Excellent.
		Totals	191	150	78.5		198	160	80.8	

[1] Strength of gas is expressed by amount of potassium cyanide used for each cubic foot of space fumigated.

The total number of apple buds treated as shown by the above table was 1,157, of which 80.6 per ct. set. The total number of checks was 1,307, of which 84.3 per ct. set. This difference is too slight to indicate that the gas seriously affected the buds when the unfavorable conditions previously referred to are taken into consideration.

A further evidence that the gas had no injurious effects is the variation in the percentage of treated buds that set. There is no relationship between the percentage of treated buds that set and the strength of gas or time of exposure.

The slight difference in growth between the treated buds and the checks is not enough to be of much importance and is probably due largely to the late date of setting them in.

TABLE XIII.—EFFECT OF HYDROCYANIC ACID GAS ON CHERRY BUDS.

Treatment.			Results.				Checks.			
Strength of gas.[1] *Gram.*	Duration of treatment.	Varieties.	No. buds treated.	No. buds set.	Per ct. set.	Growth.	No. buds.	No. buds set.	Per ct. set.	Growth.
0.18	½ hour	May Duke	27	24	88.9	Nearly equal to checks	27	26	96.3	Excellent.
0.18	½ hour	Windsor	23	14	60.9	Same as checks	23	23	100	Excellent.
0.18	½ hour	Early Richmond	24	17	70.8	Same as checks	24	24	100	Excellent.
		Totals	74	55	74.3		74	73	98.6	
0.18	1 hour	May Duke	34	26	76.5	Nearly equal to checks	34	30	88.2	Excellent.
0.18	1 hour	Windsor	25	20	80	Same as checks	25	24	96	Excellent.
0.18	1 hour	Early Richmond	35	27	77.1	Same as checks	35	35	100	Excellent.
		Totals	94	73	77.7		94	89	94.7	
0.22	½ hour	May Duke	31	26	83.9	Same as checks	34	31	91.2	Excellent.
0.22	½ hour	Windsor	20	18	90	Same as checks	20	19	95	Excellent.
0.22	½ hour	Early Richmond	24	18	75	Same as checks	24	20	83.3	Excellent.
		Totals	75	62	82.7		78	70	89.7	
0.22	1 hour	May Duke	34	28	82.4	Nearly equal to checks	39	29	74.4	Excellent.
0.22	1 hour	Windsor	20	13	65	Same as checks	22	21	95.5	Fair.
0.22	1 hour	Early Richmond	30	28	93.3	Same as checks	30	27	90	Excellent.
		Totals	84	69	82.1		91	77	84.6	
0.30	½ hour	May Duke	33	25	75.8	Nearly equal to checks	33	29	87.9	Excellent.
0.30	½ hour	Windsor	19	13	68.4	Same as checks	19	19	100	Excellent.
0.30	½ hour	Early Richmond	26	21	80.8	Same as checks	26	26	100	Excellent.
		Totals	78	59	75.6		78	74	94.9	

[1] Strength of gas is expressed by amount of potassium cyanide used for each cubic foot of space fumigated.

TABLE XIII—*Continued.*

Treatment.			Results.				Checks.			
Strength of gas.[1] *Gram.*	Duration of treatment.	Varieties.	No. buds treated.	No. buds set.	Per ct. set.	Growth.	No. buds.	No. buds set.	Per ct. set.	Growth.
0.30	1 hour	May Duke.........	38	27	71.1	Nearly equal to checks......	38	33	86.9	Excellent.
0.30	1 hour	Windsor	20	18	90	Same as checks.............	20	18	90	Excellent.
0.30	1 hour	Early Richmond...	24	16	66.7	Same as checks.............	24	22	91.7	Excellent.
		Totals	82	61	74.4		82	73	89	

[1] Strength of gas is expressed by amount of potassium cyanide used for each cubic foot of space fumigated.

Four hundred and eighty-seven cherry buds were treated of which 77.8 per ct. set. The total number of checks was 497, of which 91.7 per ct. set. While the difference in these percentages is much greater than in the case of the apples it is hardly sufficient to indicate important injury by the gas. As previously stated the somewhat unfavorable conditions under which the buds were grown, together with the fact that they were put in about two weeks late, might easily account for this difference. A more definite indication that the gas had little if any injurious effect is shown by the comparatively high percentages of buds set that were fumigated with .22 gram of cyanide. The strongest gas and longest exposure had practically no more effect than the weakest gas and shortest exposure. The growth also was in all cases equal or nearly equal to that of the checks.

TABLE XIV.—EFFECT OF HYDROCYANIC ACID GAS ON PEAR BUDS.

Treatment.			Results.				Checks.			
Strength of gas.[1] *Gram*	Duration of treatment.	Varieties.	No. buds treated.	No. buds set.	Per ct. set.	Growth.	No. buds.	No. buds set.	Per ct. set.	Growth.
0.18	½ hour	Anjou	23	14	60.9	Same as checks	31	25	80.6	Good.
0.18	½ hour	Bartlett	34	17	50	Same as checks	51	47	92.2	Good.
0.18	½ hour	Seckel	25	20	80	Nearly equal to checks	28	26	92.9	Excellent.
0.18	½ hour	Keiffer	18	13	72.2	Nearly equal to checks	32	30	93.8	Good.
		Totals	100	64	64		142	128	90.1	
0.18	1 hour	Anjou	20	18	90	Same as checks	26	21	80.9	Good.
0.18	1 hour	Bartlett	26	22	84.6	Same as checks	34	31	91.2	Excellent.
0.18	1 hour	Seckel	25	22	88	Nearly equal to checks	26	24	92.3	Excellent.
0.18	1 hour	Keiffer	21	18	85.7	Nearly equal to checks	35	33	94.3	Good.
		Totals	92	80	87		121	109	90.1	
0.22	½ hour	Anjou	25	23	92	Nearly equal to checks	27	24	88.9	Excellent.
0.22	½ hour	Bartlett	29	18	62.1	Average about 6 in. shorter than checks	34	28	82.4	Excellent.
0.22	½ hour	Seckel	23	21	91.3	Nearly equal to checks	29	27	93.1	Excellent.
0.22	½ hour	Keiffer	19	16	84.2	Nearly equal to checks	33	33	100	Good.
		Totals	96	78	81.3		123	112	91.1	
0.22	1 hour	Anjou	25	22	88	Same as checks	26	24	92.3	Good.
0.22	1 hour	Bartlett	28	20	71.4	Average about 6 in. shorter than checks	29	24	82.8	Excellent.
0.22	1 hour	Seckel	26	19	73.1	Nearly equal to checks	29	26	89.7	Excellent.
0.22	1 hour	Keiffer	17	15	88.2	Nearly equal to checks	34	28	82.4	Good.
		Totals	96	76	79.2		118	102	86.4	

[1] Strength of gas is expressed by amount of potassium cyanide used for each cubic foot of space fumigated.

0.30	½ hour	Anjou	27	19	70.4	Same as checks	28	24	85.7	Good.
0.30	½ hour	Bartlett	29	20	68.9	Same as checks	29	25	86.2	Good.
0.30	½ hour	Seckel	24	23	95.8	Nearly equal to checks	25	20	80	Good.
0.30	½ hour	Keiffer	20	14	70	Same as checks	40	30	75	Good.
		Totals	100	76	76		122	99	81.2	
0.30	1 hour	Anjou	31	25	80.6	Same as checks	33	33	100	Good.
0.30	1 hour	Bartlett	34	21	61.8	Same as checks	35	28	80	Excellent.
0.30	1 hour	Seckel	25	21	84	Same as checks	25	21	84	Excellent.
0.30	1 hour	Keiffer	28	11	39.3	Same as checks	40	33	82.5	Good.
		Totals	118	78	66.1		133	115	86.5	

The results with the pear buds are practically the same as with the cherries. Although but 75.1 per ct. of the 602 treated buds set only 87.6 per ct. of the 759 checks lived, making the difference but slightly more than with the cherries. The growth, also, although in some cases several inches shorter than the checks, averaged nearly equal to them.

TABLE XV.—EFFECT OF HYDROCYANIC ACID GAS ON PEACH BUDS.

Treatment.			Results.				Checks.			
Strength of gas.[1]	Duration of treatment.	Varieties.	No. buds treated.	No. buds set.	Per ct. set.	Growth.	No. buds.	No buds set.	Per ct. set.	Growth.
Gram.										
0.18	½ hour	Elberta	20	14	70	Same as checks............	20	15	75	Excellent.
0.18	½ hour	Early Crawford....	25	24	96	Nearly equal to checks......	25	21	84	Excellent.
0.18	½ hour	Blenheim	29	19	65.5	Same as checks............	25	22	88	Excellent.
0.18	½ hour	Early Rivers.......	14	8	57.2	Same as checks............	14	11	78.6	Excellent.
0.18	½ hour	Beer Smock........	12	10	83.3	Same as checks............	12	10	83.3	Excellent.
0.18	½ hour	Alexander	22	17	77.3	Same as checks............	22	17	77.3	Excellent.
		Totals	122	92	75.4		118	97	82.2	
0.18	1 hour	Elberta	14	11	78.6	Same as checks............	14	13	92.9	Excellent.
0.18	1 hour	Early Crawford....	22	14	63.6	Nearly equal to checks......	22	21	95.5	Excellent.
0.18	1 hour	Blenheim	16	14	87.5	Same as checks............	16	15	93.7	Excellent.
0.18	1 hour	Early Rivers.......	12	9	75	Same as checks............	12	10	83.3	Excellent.
0.18	1 hour	Beer Smock........	24	14	58.3	Same as checks............	24	21	87.5	Excellent.
0.18	1 hour	Alexander	14	10	71.4	Same as checks............	14	9	64.3	Excellent.
		Totals	102	72	70.6		102	89	87.3	
0.22	½ hour	Elberta	19	15	78.9	Same as checks............	19	17	89.5	Excellent.
0.22	½ hour	Early Crawford....	20	19	95	Nearly equal to checks......	20	19	95	Excellent.
0.22	½ hour	Blenheim	18	17	94.4	Same as checks............	18	16	88.9	Excellent.
0.22	½ hour	Early Rivers.......	14	14	100	Same as checks............	14	14	100	Excellent.
0.22	½ hour	Beer Smock........	28	21	75	Same as checks............	28	23	82.2	Excellent.
0.22	½ hour	Alexander	21	13	61.3	Same as checks............	21	16	76.2	Excellent.
		Totals	120	99	82.5		120	105	87.5	
0.22	1 hour	Elberta	17	16	94.1	Same as checks............	17	11	64.7	Excellent.
0.22	1 hour	Early Crawford....	23	17	73.9	Nearly equal to checks......	23	18	78.3	Excellent.
0.22	1 hour	Blenheim	23	18	78.3	Same as checks............	23	17	73.9	Excellent.

0.22	1 hour	Early Rivers	25	19	76	Same as checks	25	19	76	Excellent.
0.22	1 hour	Beer Smock	15	8	53.3	Same as checks	15	12	80	Excellent.
0.22	1 hour	Alexander	19	16	84.2	Same as checks	19	15	78.9	Excellent.
		Totals	122	94	77.1		122	92	75.4	
0.30	½ hour	Elberta	20	16	80	Same as checks	20	16	80	Excellent.
0.30	½ hour	Early Crawford	27	24	88.9	Nearly equal to checks	27	21	77.8	Excellent.
0.30	½ hour	Blenheim	24	10	41.7	Same as checks	24	22	91.7	Excellent.
0.30	½ hour	Early Rivers	26	9	34.6	Same as checks	26	24	92.3	Excellent.
0.30	½ hour	Beer Smock	20	6	30	Same as checks	20	16	80	Excellent.
0.30	½ hour	Alexander	18	13	72.2	Same as checks	18	8	44.5	Excellent.
		Totals	135	78	57.8		135	107	79.3	
0.30	1 hour	Elberta	13	11	84.6	Same as checks	13	13	100	Excellent.
0.30	1 hour	Early Crawford	28	22	78.6	Nearly equal to checks	28	25	89.3	Excellent.
0.30	1 hour	Blenheim	33	9	27.2	Same as checks	33	31	93.9	Excellent.
0.30	1 hour	Early Rivers	22	13	59.1	Same as checks	22	18	81.8	Excellent.
0.30	1 hour	Beer Smock	19	15	78.9	Same as checks	19	13	68.4	Excellent.
0.30	1 hour	Alexander	16	9	56.3	Same as checks	16	13	81.3	Excellent.
		Totals	131	79	60.3		131	113	86.2	

[1] Strength of gas is expressed by amount of potassium cyanide used for each cubic foot of space fumigated.

There is evidence of injury to the peach buds with the strong gas. Evidently the gas at a strength of .22 gram of cyanide with an exposure of one hour did no harm, as the percentage of treated buds set is greater than the percentage of checks that set. But there is a decided falling off in the percentage when the gas was used at .3 grams of cyanide indicating that the gas at this strength injured the buds. Comparing the whole number of buds treated with the checks, however, there is but little difference between the peaches, pears and cherries. The whole number of peach buds treated was 732, of which 70 2 per ct. set. The whole number of checks was 728, of which 82.8 per ct. set.

The growth of the treated peach buds was in nearly all cases equal to the checks.

Table XVI.—Effect of Hydrocyanic Acid Gas on Plum Buds.

Treatment.			Results.				Checks.			
Strength of gas.[1]	Duration of treatment.	Varieties.	No. buds treated.	No. buds set.	Per ct. set.	Growth.	No. buds.	No. buds set.	Per ct. set.	Growth.
Gram.										
0.18	½ hour	Italian Prune	30	21	70	Same as checks	34	25	73.5	Good.
0.18	½ hour	Reine Claude	26	19	73.1	Same as checks	29	27	93.1	Good.
0.18	½ hour	Bradshaw	24	20	83.3	Nearly equal to checks	26	25	96.2	Good.
0.18	½ hour	Shropshire Damson	33	26	78.7	Nearly equal to checks	40	32	80	Fair.
0.18	½ hour	Burbank	37	28	75.7	Slightly better than checks	41	40	97.6	Excellent.
0.18	½ hour	Yellow Spanish	32	23	71.9	Nearly equal to checks	32	31	96.9	Excellent.
0.18	½ hour	Yellow Egg	29	27	93.1	Same as checks	29	13	44.8	Excellent.
0.18	½ hour	Lombard	22	20	90.9	Same as checks	21	19	90.5	Excellent.
0.18	½ hour	De Soto	27	26	96.3	Same as checks	30	25	83.3	Excellent.
		Totals	260	210	80.8		282	237	84	
0.18	1 hour	Italian Prune	28	25	89.3	Same as checks	34	25	73.5	Good.
0.18	1 hour	Reine Claude	27	24	88.9	Same as checks	34	24	70.6	Good.
0.18	1 hour	Bradshaw	26	23	88.5	Same as checks	26	26	100	Good.
0.18	1 hour	Shropshire Damson	39	34	87.2	Nearly equal to checks	39	39	100	Fair.
0.18	1 hour	Burbank	38	22	57.9	Same as checks	41	41	100	Good.
0.18	1 hour	Yellow Spanish	40	28	70	Nearly equal to checks	40	39	97.5	Excellent.
0.18	1 hour	Yellow Egg	21	17	81	Same as checks	20	13	65	Excellent.
0.18	1 hour	Lombard	23	20	87	Same as checks	25	22	88	Excellent.
0.18	1 hour	De Soto	30	29	96.7	Nearly equal to checks	36	31	86.1	Excellent.
		Totals	272	222	81.6		298	260	89	

[1] Strength of gas is expressed by amount of potassium cyanide used for each cubic foot of space fumigated.

TABLE XVI—*Continued.*

Treatment.			Results				Checks.			
Strength of gas.[1] *Gram.*	Duration of treatment.	Varieties.	No. buds treated.	No. buds set.	Per ct. set.	Growth.	No. buds.	No buds set.	Per ct. set.	Growth.
0.22	½ hour	Italian Prune	29	22	75.9	Same as checks	32	27	84.4	Good.
0.22	½ hour	Reine Claude	27	19	70.4	Same as checks	27	20	74.1	Good.
0.22	½ hour	Bradshaw	28	28	100	Same as checks	30	28	93.3	Good.
0.22	½ hour	Shropshire Damson	37	26	70.3	Nearly equal to checks	40	33	82.5	Fair.
0.22	½ hour	Burbank	35	22	62.9	Same as checks	35	27	77.1	Good.
0.22	½ hour	Yellow Spanish	18	16	88.9	Nearly equal to checks	18	17	94.5	Excellent.
0.22	½ hour	Yellow Egg	29	25	86.2	Same as checks	30	21	70	Excellent.
0.22	½ hour	Lombard	25	22	88	Same as checks	27	24	88.9	Excellent.
0.22	½ hour	De Soto	29	26	99.7	Nearly equal to checks	30	25	83.3	Excellent.
		Totals	257	206	80.2		269	222	82.5	
0.22	1 hour	Italian Prune	28	23	82.1	Same as checks	35	29	82.8	Good.
0.22	1 hour	Reine Claude	21	17	81	Same as checks	26	23	88.5	Good.
0.22	1 hour	Bradshaw	27	18	66.7	Slightly better than checks	29	27	93.1	Good.
0.22	1 hour	Shropshire Damson	37	34	91.9	Nearly equal to checks	42	39	92.9	Poor.
0.22	1 hour	Burbank	35	25	71.4	Same as checks	40	37	92.5	Good.
0.22	1 hour	Yellow Spanish	34	25	73.5	Nearly equal to checks	34	34	100	Excellent.
0.22	1 hour	Yellow Egg	22	21	95.5	Same as checks	25	20	80	Excellent.
0.22	1 hour	Lombard	18	17	94.4	Same as checks	28	24	85.7	Fair.
0.22	1 hour	De Soto	34	25	73.5	Nearly equal to checks	37	32	86.5	Excellent.
		Totals	256	205	80.1		292	265	90.8	
0.30	½ hour	Italian Prune	24	18	75	Same as checks	25	18	72	Good.
0.30	½ hour	Reine Claude	29	22	75.9	Same as checks	36	22	61.1	Good.
0.30	½ hour	Bradshaw	26	25	96.2	Slightly better than checks	28	24	85.7	Good.
0.30	½ hour	Shropshire Damson	30	24	80	Nearly equal to checks	40	27	67.5	Poor.
0.30	½ hour	Burbank	36	29	80.6	Same as checks	48	41	85.4	Good.

0.30	½ hour	Yellow Spanish.....	28	24	85.7	Nearly equal to checks......	28	26	92.9	Excellent.
0.30	½ hour	Yellow Egg.........	24	20	83.3	Same as checks............	26	24	92.3	Excellent.
0.30	½ hour	Lombard	21	19	90.5	Same as checks............	22	18	81.8	Fair.
0.30	½ hour	De Soto...........	27	26	96.3	Same as checks............	27	26	96.3	Excellent.
		Totals	245	207	84.5		280	226	80.7	
0.30	1 hour	Italian Prune.......	21	15	71.4	Same as checks............	31	25	80.7	Good.
0.30	1 hour	Reine Claude.......	22	18	81.8	Same as checks............	23	17	73.9	Good.
0.30	1 hour	Bradshaw	21	19	90.5	Slightly better than checks..	24	22	91.7	Good.
0.30	1 hour	Shropshire Damson.	29	22	75.9	Nearly equal to checks......	32	20	62.5	Good.
0.30	1 hour	Burbank	35	22	62.9	Same as checks............	35	31	88.6	Good.
0.30	1 hour	Yellow Spanish.....	19	16	84.2	Nearly equal to checks......	19	18	94.7	Excellent.
0.30	1 hour	Yellow Egg........	23	20	87	Same as checks............	24	21	87.5	Excellent.
0.30	1 hour	Lombard	11	9	81.8	Same as checks............	22	16	72.7	Fair.
0.30	1 hour	De Soto...........	34	29	85.3	Same as checks............	42	37	88.1	Excellent.
		Totals	215	170	79.1		252	207	82.8	

[1] Strength of gas is expressed by amount of potassium cyanide used for each cubic foot of space fumigated.

The results with the plum buds were practically the same as with the apples. The gas at a strength of .3 gram of cyanide had practically no more effect than at .18 gram. There was also but little difference in the percentage of treated buds that set and the percentage of the checks that set. The total number of treated buds was 1505, of which 81.1 per ct. set, and the total number of checks 1673, of which 84.7 per ct. set, making a difference of only 3.6 per ct. in favor of the checks. As with the other varieties the growth was nearly equal to the checks.

SERIES II. EFFECT OF THE GAS UPON THE SAN JOSE SCALE.

The experiments were conducted in four different orchards in the vicinity of Geneva. Some of the trees were fumigated in December and the remainder in June. But one treatment was made. The results are shown in the following tables.

ORCHARD II: PEARS. ORCHARD IV: PEACHES.

Weather during tests in Table XVII.—Winter treatment. Trees treated Dec. 13 to 24, average temperature 27°, cloudy with light rains or snow. Weather during the week following cloudy with average temperature of 29°.

TABLE XVII.—FUMIGATION TESTS ON INFESTED PEAR AND PEACH TREES.

Trees.					
Number treated.	Kinds.	Degree of infestation.	Strength of gas. *Gram.*	Time of treatment.	Results.
	PEAR:				
6	Bartlett.	5 extensively and 1 moderately infested.	0.18	½ hour	Scales not affected. Trees uninjured.
7	Bartlett.	3 extensively, 2 moderately and 2 slightly infested.	0.18	1 hour	Scales not affected. Trees uninjured.
8	Bartlett.	5 extensively, 2 moderately and 1 slightly infested.	0.25	½ hour	Scales apparently affected but many live ones found. Trees uninjured.

TABLE XVII—*Continued*

Trees. Number treated.	Kinds.	Degree of infestation.	Strength of gas.	Time of treatment.	Results.
			Gram.		
8	Bartlett.	2 extensively, 4 moderately and 2 slightly infested.	0.25	1 hour	Scales apparently affected but many live ones found. Trees uninjured.
7	Bartlett.	4 extensively and 3 moderately infested.	0.30	½ hour	Scales dead. Trees uninjured.
7	Bartlett.	2 extensively and 5 moderately infested.	0.30	1 hour	Scales dead. Trees uninjured.
	PEACH:				
1	Var. unknown.	Slightly infested	0.18	½ hour	Scales not affected. Tree uninjured.
1	Var. unknown.	Slightly infested	0.18	1 hour	Tree dead.
1	Var. unknown.	Slightly infested	0.30	½ hour	Tree dead.
1	Var. unknown.	Slightly infested	0.30	1 hour	Tree dead.

The results in these experiments were unexpected. Neither the .18 gram or .25 gram had any appreciable effect. The live scales were as numerous and active on the treated trees as on the checks. There was a decided difference, however, in the trees treated with the .3 gram. The scales were dead on all the trees. The peaches, although in fairly good condition, succumbed quickly to the gas. The limited number of peach trees used makes a repetition of the experiment desirable.

ORCHARD VI: PLUMS.

This orchard consists of 22 plum trees, European varieties, which were set out about ten years ago. They have been well cared for and have been in thriving condition until recently when they began to show the effects of the San José scale. When the experiments were begun they were all extensively infested and hence weakened by the scale. The treatment and results in this orchard are shown in Table XVIII.

Weather during tests in Table XVIII.—Spring treatment. Trees fumigated June 6 to 8. Average temperature 63°, cloudy with slight rain. Weather during the week following usually fair with slight rain on one day. Average temperature 70°.

TABLE XVIII.—SPRING FUMIGATION OF INFESTED PLUM TREES.

Trees. No. treated.	Trees. Kinds.	Trees. Degree of infestation.	Str'gth of gas.	Duration of treatment.	Results.	Checks.
			Gram.	Hours.		
	PLUMS:					
4	European.	Extensively infested.	0.18	½	Scales dead. Trees uninjured.	Checks consisted of 4 extensively infested trees. The scales bred very rapidly during the summer, and these trees are now encrusted with them.
4	European.	Extensively infested.	0.18	1	Scales dead. Trees uninjured.	
3	European.	Extensively infested.	0.25	½	Scales dead. Foliage slightly under normal. No other injury.	
3	European.	Extensively infested.	0.25	1	Scales dead. Foliage slightly under normal. No other injury.	
2	European.	Extensively infested.	0.30	½	Scales dead. Foliage slightly under normal. No other injury.	
2	European.	Extensively infested.	0.30	1	Scales dead. Foliage slightly under normal. No other injury.	

ORCHARD VII: PLUMS.

The 86 trees included in this experiment, and constituting Orchard VII, form a portion of one of the large orchards of Western New York. It was set out about eight years ago and has been under the best of cultivation. Two years ago two trees near the middle of the orchard were discovered quite seriously infested with the San José scale. From these trees it

had spread in all directions until eighty-six were infested before the spreading was discovered.

The treatment and results are shown in Table XIX. Trees fumigated June 16 to 24. Average temperature 71°, cloudy.

TABLE XIX.—SPRING FUMIGATION OF PLUM TREES.

Trees.			Str'gth of gas.	Duration of exposure.	Results.	Checks.
No. treated.	Varieties.	Degree of infestation.				
			Gram.	*Hours.*		
84	PLUMS: Diamond.	2 extensively and remainder slightly infected.	0.25	½	Scales dead. Trees uninjured. Fruit crop equal to checks.	A large number of Diamond plum trees which bore more than average crop of fruit.

The results shown by Tables XVIII and XIX are strongly in contrast to those of Table XVII where .18 and .25 gram had no appreciable effect upon the scales. In the latter case, however, the trees were fumigated during the winter, while the former were fumigated in June. As the scales were killed by a half hour's treatment in June with the gas at a strength of only .18 gram, the indications are that, as might be expected, the scales are more susceptible to the treatment in the spring than during the winter. The weather conditions were such that in each case the trees were damp at the time of treatment. It is to be noted also that although the trees were in foliage when fumigated none were injured and they bore more than an average crop of fruit the following season.

GENERAL SUMMARY OF FUMIGATION EXPERIMENTS.

The experiments with buds while not entirely satisfactory owing to the somewhat unfavorable conditions surrounding the treated buds, gave sufficiently uniform results to indicate clearly that the gas was harmless except in the case of the peaches which were evidently injured slightly by the strong gas. Taken as a whole there is but little difference in the percentage of treated buds that set and the checks that were unharmed. In

all 4483 buds were treated 78 per ct. of which set. The checks numbered 4864 of which 85.5 per ct. set, thus making but a slight difference in favor of the checks, a difference which might be expected from the unusual exposure of the treated buds.

The experiments with the scale gave somewhat unexpected results in that the scales were practically unaffected by winter fumigation with the gas at a strength less than .3 gram of cyanide per cubic foot of air space. This result has an important bearing upon the winter fumigation of nursery stock. To be certain of killing the hibernating scales in this latitude the gas should be used at the above strength.[5]

The spring treatment gave different results. The gas at a little more than half the strength (.18 gram) killed the scales in every case and did not injure the foliage.

RECOMMENDATIONS.

Obviously the first step in combating the San José scale is to prevent infestation. As the most fruitful source of infestation is nursery stock it is plainly of the greatest importance to prevent the spread of infested stock. Fumigation with hydrocyanic acid gas together with careful inspection and clean cultivation are our best safeguards. If stock is to be fumigated too much pains cannot be taken to have all conditions right for thorough work. Above all else the fumigating house should be gas tight. For winter fumigation the gas should be used at a strength of .3 gram of cyanide. For early spring treatment a strength of .18 to .2 gram of cyanide will be sufficient to kill the scales.

An additional safeguard in the nursery is the fumigation of bud sticks, scions, etc., especially if such stock has been brought from infested localities. The gas at a strength of .22 gram of cyanide can be safely used on the common varieties of fruits and probably all varieties without danger of injury.

---

[5]For directions for computing the amount of cyanide to use for a given number of cubic feet of air space see Bulletin No. 194 of this Station, p. 382.

As the scale is distributed locally by such agencies as insects, birds and the wind a careful watch should be kept in the orchard for its appearance. Orchard trees that have become infested if considered too valuable to destroy may be treated either by applying a wash or by fumigation with hydrocyanic acid gas. The former method is the only one practical for large trees, such as full-grown apples, and may be employed for smaller trees as well. Crude petroleum is one of the best washes that has been extensively used in the East, although as noted on a subsequent page, a number of others have recently given promising results. Crude petroleum may be used upon apple, pear and cherry trees, in an emulsion with water, in the proportion (40 per ct. of petroleum) required to kill the scale, without danger of serious injury provided the application is made in early spring. Plums may also be treated with the petroleum-water emulsion but there is more danger of injury. Peaches should not be treated with the emulsion stronger than 25 per ct. petroleum. For summer treatment a 25 per ct. emulsion may be used, with reasonable certainty of killing the scales that are reached by the spray. When purchasing crude petroleum it should be remembered that it is safer to use an oil having a specific gravity of 43° than lower.

The principal advantage of fumigation over treatment with any of the washes is the thoroughness with which the gas does the work. If properly done, probably every scale will be killed by fumigation while it is very difficult, if not impossible, to hit all of them with a spray. The use of the gas in the orchard is practically limited, however, to comparatively small trees because of the expense and difficulty of fumigating large ones. Trees that can be cut back to about twelve or fourteen feet in height by eight or nine feet in diameter can be easily and cheaply fumigated.

III. OTHER PROMISING INSECTICIDES.

The economic importance of scale insects as a group has resulted in unusual efforts being made to develop methods for their control. As a result various compounds are being devised and tested from time to time with the hope of finding a cheaper and more effectual way of combating these insects than any that has yet been devised. Among the compounds that give promise of success are the following:

Whale oil soap and crude petroleum compound.—Both whale oil soap and crude petroleum are known to have great insecticidal value and hence it would be supposed that a combination of the two would give highly satisfactory results. The experiments thus far, however, that have come to the writer's knowledge, have not given altogether satisfactory results. A series of experiments by Felt,[6] gave no better results than he had obtained with a plain 20 per ct. emulsion with water. In these experiments, however, the emulsion was not used very strong as but one pound of soap was used to each four gallons of water. This was emulsified in a "kerowater" pump with a small amount of oil, the pump being set to discharge but 10 per ct. of crude petroleum.

This compound is undoubtedly worthy of further experiment. It is not improbable that a stronger emulsion would prove more effectual.

Lime, sulphur and salt wash.—This compound has been used extensively and with much success in California. The prolonged periods of dry weather characteristic of that country are especially favorable to the use of compounds of this kind. Experiments with this insecticide in the East have not given very satisfactory results as a rule. A prominent exception, however, is a series of experiments by Marlatt, conducted at Washington, and published in Bul. 30, N. S., U. S. Dept. Agr., Div. of Entomology, pp. 34–36, which gave very promising results. In explanation of the unusual success of the treatment Dr. Marlatt states

[6] Bulletin N. Y. State Museum, No. 46, Vol. 9, p. 337.

(p. 36), that the results were evidently due largely to the unusually favorable weather conditions, as there were no rains sufficiently heavy to wash off the lime for nearly three weeks after the applications were made. The statement is also made that if a week or two of dry weather following the applications could be counted on, the lime, sulphur and salt wash would be as effectual here in the East as on the Pacific coast.

The wash was made after the following formula, the ingredients being steam boiled together in a barrel and applied hot.

Lime	30	pounds
Sulphur	20	"
Salt	15	"
Water	60	gallons

Kerosene-lime emulsion.—Several experiments with this compound were also made by Dr. Marlatt, who gives a brief account of them in the bulletin just referred to, pages 37–38. The mixture was first suggested to him by Professor Galloway, who prepared it after the following formula:

Fresh lime	4	pounds
Water	5	gallons
Kerosene	1	gallon

" Slack the lime slowly with small quantities of water in order to get a creamy solution. When thoroughly slacked dilute to 5 gallons, add 1 gallon of kerosene and churn until emulsified (one or two minutes)."

The experiments were considered as indicating this compound to be a promising one. The suggestion is made, however, that it is possible that more lime would have been an advantage, making a better emulsion and a slightly heavier wash.

IV. A MODIFICATON OF THE STATION FUMIGATOR.

A simple method of fastening the door of the tree fumigator described in Bulletin 181 of this Station has been suggested and found to give so much better satisfaction than the old one that it is considered worthy of special mention.

The improvement does away with the buttons. In their places stout strips are used which extend across the door to the margin of the fumigator as shown in Plates XIII and XIV. These strips are of hard wood, two inches wide and three-fourths of an inch thick. The projecting ends are cut on an angle to fit against corresponding surfaces of the blocks fastened to the door casing as at *a*, Fig. 1. The blocks are of the shape shown at *b*. When the strips and blocks are in place and the door is being forced into position the downward pressure brings it against the supporting sides, top and bottom of the fumigator.

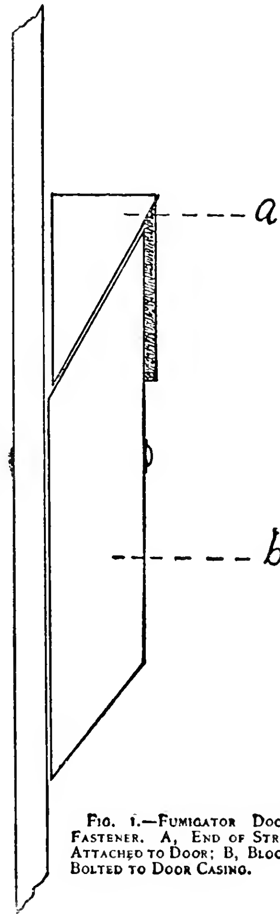


FIG. 1.—FUMIGATOR DOOR FASTENER. A, END OF STRIP ATTACHED TO DOOR; B, BLOCK BOLTED TO DOOR CASING.

With these fastenings the door should extend to the top of the fumigator instead of within two or three inches of the top as when the buttons are used. This is to permit it to slip in place easily. The strip across the top against which the top of the door rests should be at least three inches wide and the corresponding strip of the door the same width. Both should be covered with heavy felt as described in Bulletin 181.

Both strips and blocks should be made of hard wood and should be bolted on securely. It is of especial importance also

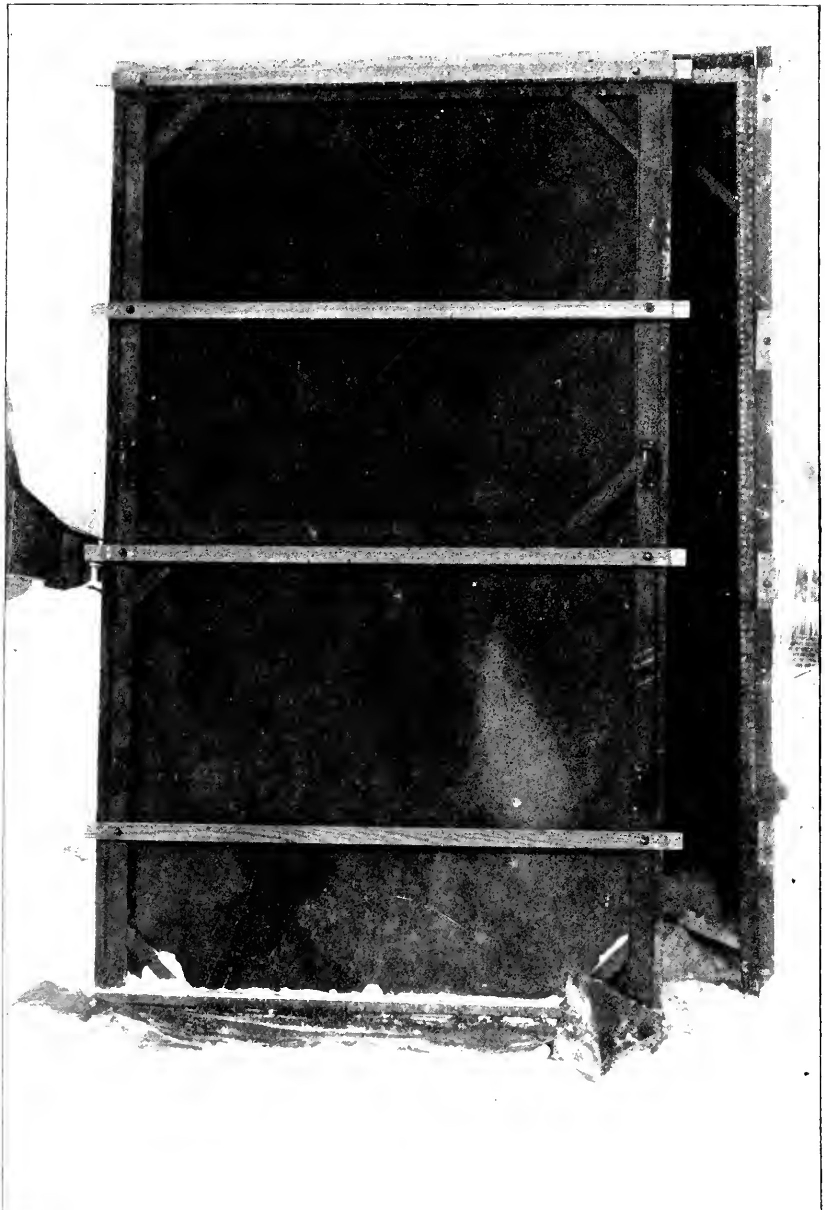


Plate XIII.—Door Removed Showing Projecting Ends of Strips Cut on an Angle.

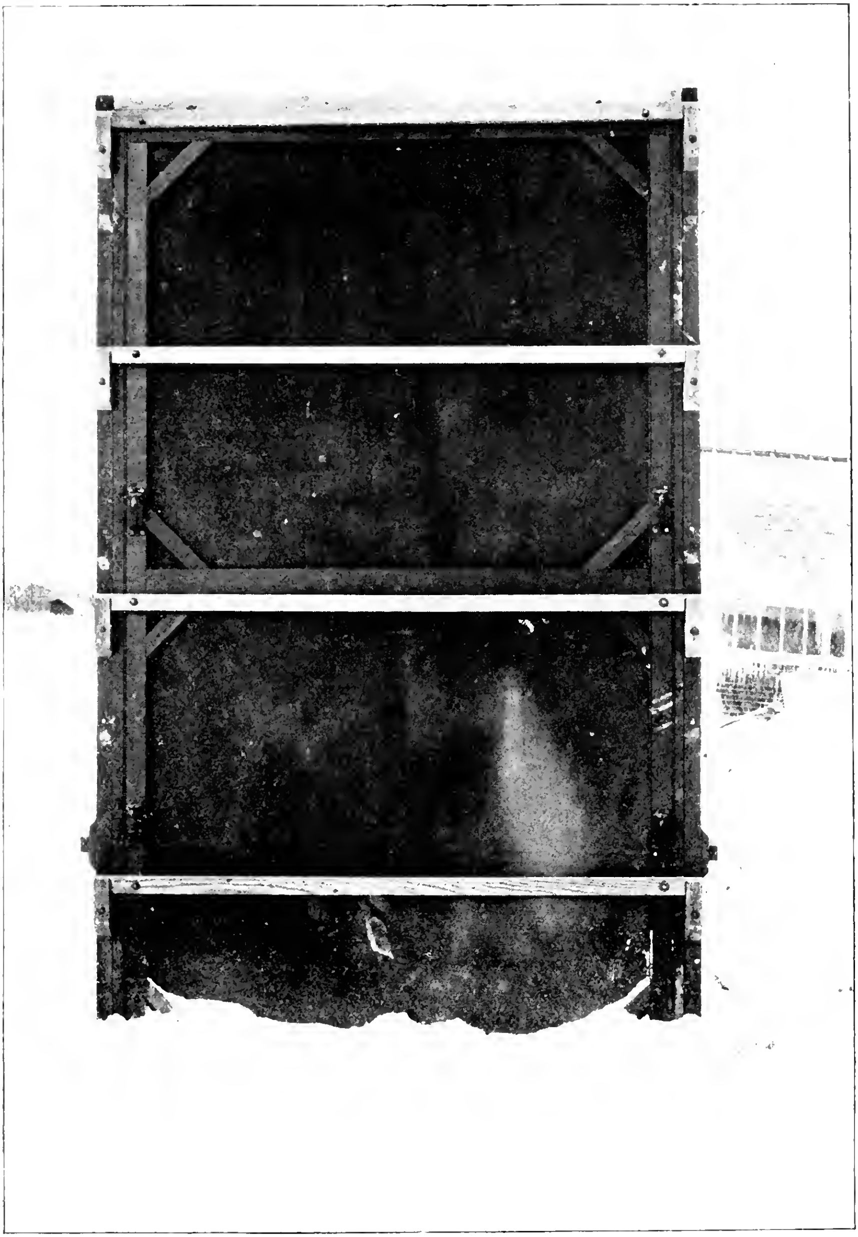


PLATE XIV.—DOOR IN POSITION.

that the blocks be so placed that when the door is forced into position it will almost but not quite reach the metal supports at the bottom.[7] This will admit of some wear before the door is down as far as it will go.

As shown in the illustrations, four strips are required. The upper one should be placed at the top of the door so as to press the two surfaces of felt as close together as possible, thus lessening the possibility of leakage of gas. To make the pressure on the upper part of the door as great as possible the upper strip should be warped somewhat and then sprung into place.

If preferred metal lugs may be cast, together with corresponding supports, and used in place of the strips and blocks. The principal advantage over the wooden fasteners would be that they would wear longer.

To put the door in place it is only necessary to lift it so that the ends of the cross strips may drop into the fasteners. Its own weight will bring it nearly into place, and it will require but little additional force to drive it down as far as necessary. The handling of the door will be facilitated if the surfaces of the fasteners coming together are lubricated.

The principal advantage of this fastener over the old is the ease and speed with which it permits the door to be put into place. It takes but a very few seconds. No ladder is required and the delay and consequent expense of turning each button into place is avoided. The door is held in place as securely as with the buttons, and we have found by careful tests that with the new fasteners there is no more danger of leakage of gas than before.

---

[7] See Bulletin 181, page 139.

TREATMENT FOR SAN JOSÉ SCALE IN ORCHARDS.*

I. ORCHARD FUMIGATION.

F. A. SIRRINE.

SUMMARY.

It is unsafe to leave trees in orchards exposed to action of hydrocyanic acid gas for periods of twelve hours.

With perfect covers, debarring accidents, it is possible to kill every living specimen of pernicious scale on medium sized fruit trees without injury to the trees and thus to exterminate the pest in isolated sections.

With large pieces of potassium cyanide and an excess of acid and water, rapid and uniform action results.

Double the amount of potassium cyanide usually recommended for nursery fumigation should be used in orchard fumigation.

Tents have less waste space and require less chemicals than other forms of coverings, but neither accurate nor thorough work can be done with them.

Under favorable conditions thorough work can be done with box fumigators, but they require more chemicals than tents. They have the advantage of fixed dimensions.

Cost of fumigation depends upon so many variable factors that it cannot be fixed.

INTRODUCTION.

Undoubtedly no one insect has attracted more attention during the past few years than the Pernicious scale-insect (*Aspidiotus perniciosus*), generally called "San José scale." As this pest has been widely distributed to most sections of the

*A reprint of Bulletin No. 209.

country its treatment and control have been the subject of a large number of publications. Unfortunately a number of conflicting and misleading results have been obtained and published. As a result, orchardists are often at a loss to know whether the expense and the chances of failure are not too great to warrant undertaking any treatment, or are unable to decide correctly between different methods. We feel justified, therefore, in adding another chapter on the treatment of this notorious pest. In addition it is desirable to record the conditions and results met with in this section of the State (Long Island).

OBJECT OF TESTS.

The object of making the following tests was not only to determine the amounts of potassium cyanide that should be used in orchard work, together with its effect on trees and insects, but to determine whether it is possible to exterminate this pest over small isolated areas and at same time to simplify and cheapen the method so that orchardists would find fumigation feasible. Incidental to this work were tests on time of chemical action, on kinds of apparatus used, and on cost

HISTORY OF TESTS.

During the winter of 1899–1900, about 20 apple, 14 cherry, 201 peach, 6 pear, and 25 plum trees (in the orchard) were fumigated by means of tents. As it was not only impossible to estimate accurately the amount of space enclosed by a tent when placed over a tree, but was also found impracticable to prevent frequent leakage of gas from the tents, caused by constant wearing and puncturing by the branches, the work was discontinued until the winter of 1900–1901, at which time folding fumigators having fixed dimensions were constructed and used. The plums, pears and cherries, which were separated from the main orchard by a high embankment and were distant one-eighth mile, were not treated again; but the apple and peach trees, treated the previous winter, were refumigated.

EFFECT OF THE GAS ON TREES.

In the preliminary work on fumigation, in California, especially of citrus trees, all injury to the leaves of the trees was supposed to result from decomposition of the gas by sunlight and heat. As a result fumigation is usually done at night in that section, although it was found that by the use of black tents the work could be done in the day time with less injury than with uncolored tents. In the east the majority of the tests have been made with black tents at a season of the year when the trees were dormant, with the result that there was little or no danger of injury from the conditions that orange growers have to contend with. The principal injuries to deciduous trees result from other causes, such as too heavy charges of chemicals, over exposure or treatment after leaves have begun to expand.

In the following tables are shown some of the effects of different amounts of chemicals allowed to act for varying lengths of time, together with notes on the same. In a study of these tables the following notes will be of assistance:

The chemical abbreviation KCN is used for potassium cyanide, the chemically pure (approximately 98 per ct.) being used in all cases. In most instances the maximum exposures were made during the noon hour and comparatively few trees were treated for long periods; in addition the number of trees receiving heavy charges of KCN were small; hence the tables cannot be averaged.

The orchards in which the tests were made consisted of a mixture in one case of apple, cherry, peach, pear and plum; in the other of apple, cherry, chestnut, peach and walnut. In the first, a small orchard, the trees were set haphazard; while in the second, a peach orchard, the peach trees in every other row alternated with apple, cherry, chestnut or walnut. No definite order was followed in setting the alternating trees; and as a result there were but few apples, walnuts, etc., and these were often widely scattered.

Under these conditions it was more convenient to keep a record of the trees and the notes on the same by number instead of by charts, the trees being numbered consecutively in each orchard, without reference to the kind of tree.

All trees under test, of whatever kind, were treated while the fumigators were near them, without returning to the same section of the orchard at different times. The orchard was treated in sections during the winter of 1900–1901, so that some trees of each kind could be fumigated with different amounts of KCN at different periods—while dormant and when the buds were opening.

Dates given in the tables should not be taken as proper time for treatment except in sections of the country which have relatively the same temperature.

TABLE I.—APPLE TREES TREATED UNDER FUMIGATORS, 1901.

Date.	Amt. of KCN per 100 cu. ft.		Time treated.		No. of trees.	Results.
			Min.	Max.		
	Grams.	*Ozs.*	*Min.*	*Min.*		
Mar. 23..	15	.53	45	45	1	No injury.
Mar. 18..	20	.70	45	45	1	No injury.
Mar. 19..	20	.70	30	35	3	No injury.
Mar. 20..	20	.70	45	45	1	No injury.
Mar. 23..	20	.70	30	90	3[1]	No injury.
Apr. 5..	20	.70	30	60	2	No injury.
Apr. 8..	20	.70	30	30	2	No injury.
Apr. 9..	20	.70	30	30	1	No injury.
Apr. 12..	20	.70	30	30	1	No injury.
Total number treated with 20 grams					14	
Mar. 16..	25	.88	30	45	4	No injury.
Mar. 18..	25	.88	55	55	1	No injury.
Mar. 19..	25	.88	35	70	2	No injury.
Mar. 23..	25	.88	45	50	2	No injury.
Mar. 27..	25	.88	15	40	2[2]	No injury.
Mar. 28..	25	.88	30	75	2	No injury.
Apr. 2..	25	.88	30	90	11[1]	No injury.
Apr. 5..	25	.88	30	45	15	No injury.
Apr. 8..	25	.88	30	45	3	No injury.
Apr. 9..	25	.88	30	30	1	No injury.
Apr. 12..	25	.88	30	40	6	No injury.
Apr. 13..	25	.88	30	30	3	No injury.
Total number treated with 25 grams					51	
Mar. 25..	75	2.64	45	45	1[3]	Very scaly, thrown out.

[1] One tree exposed all night to action of gas.
[2] Fumigator blown off one tree at end of 15 minutes. Unless anchored when wind was heavy, the fumigator is not only liable to jump but in this case was blown from the tree.
[3] Tree was removed after treatment by owner without consulting us.

TABLE II.—CHESTNUT (PARAGON) TREATED UNDER FUMIGATORS, 1901.

Date.	Amt of KCN per 100 cu. ft.		Time treated.		No. of trees.	Results.
			Min.	Max.		
	Grams.	*Ozs.*	*Min.*	*Min.*		
Mar. 19..	20	.70	40	45	2	No injury, May 1.
Apr. 5..	20	.70	35	70	6	No injury, May 1.
Mar. 18..	25	.88	40	45	3	No injury, May 1.

TABLE III.—PEACH TREES TREATED UNDER FUMIGATORS, 1901.

Date.	Amt. of KCN per 100 cu. ft.		Time treated.		No. of trees.	Results.
			Min.	Max.		
	Grams.	*Ozs.*	*Min.*	*Min.*		
Mar. 19..	15	.53	60	60	1	Tree badly infested. No injury.
Mar. 23..	15	.53	55	55	1	No injury.
Mar. 25..	15	.53	50	50	1	No injury.
Apr. 2..	15	.53	40	40	1	No injury.
Apr. 12..	15	.53	30	60	2	One tree treated 60 minutes has a number of its lower branches dead, apparently all due to injury by scale.
Total number treated with 15 grams					6	
Mar. 18..	20	.70	30	75	17[1]	No injury.
Mar. 19..	20	.70	30	90	14[1]	No injury.
Mar. 20..	20	.70	30	60	4	No injury.
Mar. 23..	20	.70	30	85	14[1]	One tree exposed all night; on June 3, shows tips of twigs without leaves and no living weeds or grass around base. Other trees uninjured.
Mar. 25..	20	.70	30	75	21[1]	No injury.
Mar. 27..	20	.70	30	45	4	No injury.
Mar. 28..	20	.70	30	80	11	No injury.
Apr. 2..	20	.70	30	65	9	No injury.
Apr. 5..	20	.70	25	90	9[1]	One tree exposed all night; May 24, has terminals killed back 12 to 18 inches, similar to tree shown in Plate XVI. All plants around base of tree killed. Other trees uninjured.
Apr. 8..	20	.70	30	30	3	No injury.
Apr. 9..	20	.70	30	90	5	No injury.
Apr. 12..	20	.70	30	45	6	No injury.
Apr. 13..	20	.70	30	30	3	No injury.
Total number treated with 20 grams					120	

[1] Two trees treated Mar. 18, two Mar. 19, one Mar. 23, two Mar. 25 and one Apr. 5 were exposed to gas all night.

Table IV.—Peach Trees Treated Under Fumigators, 1901.

Date.	Amt. of KCN per 100 cu. ft.		Time treated.		No. of trees.	Results.
	Grams.	*Ozs.*	Min. *Min.*	Max. *Min.*		
Mar. 16..	25	.88	30	50	5	No injury.
Mar. 18..	25	.88	30	90	11[1]	No injury.
Mar. 19..	25	.88	30	90	17[1]	No injury.
Mar. 20..	25	.88	30	60	4	No injury.
Mar. 23..	25	.88	30	90	15[1]	No injury.
Mar. 25..	25	.88	30	90	8[1]	No injury.
Mar. 27..	25	.88	30	45	3	No injury.
Mar. 28..	25	.88	30	30	3	No injury.
Apr. 2..	25	.88	30	90	30	No injury.
Apr. 5..	25	.88	30	90	41[1]	One tree exposed all night; on May 13 has terminals killed back 12 to 18 inches. Other trees uninjured.
Apr. 8..	25	.88	30	40	9	No injury.
Apr. 9..	25	.88	30	45	10	No injury.
Apr. 12..	25	.88	30	75	15[1]	One tree exposed 75 minutes; on May 13 starting as if injured; May 24 shows a few tips of branches without leaves. Other trees uninjured.
Apr. 13..	25	.88	30	30	8	No injury.
Apr. 17..	25	.88	30	30	1	No injury.
Total number treated with 25 grams					181	
Mar. 25..	50	1.76	30	90	8[2]	No injury.
Mar. 27..	50	1.76	30	45	5	No injury.
Mar. 28..	50	1.76	30	80	6[2]	No injury.
Apr. 9..	50	1.76	30	60	2	One badly infested tree treated 60 min., on Apr. 28 shows buds on infested branches dead, and on May 13 no injury except on such branches. Other tree, treated 30 min., uninjured.
Total number treated with 50 grams					21	

[1] One tree treated Mar. 18, one Mar. 19, two Mar. 23, one Mar. 25 and one Apr. 5 exposed to gas all night; one Apr. 12 exposed 75 minutes.

[2] One tree treated Mar. 25 exposed to gas all night; one tree Mar. 28 exposed 60 minutes, another 80 minutes.

TABLE V.—PEACH TREES TREATED UNDER FUMIGATORS, 1901.

Date.	Amt. of KCN per 100 cu. ft.		Time treated.		No. of trees.	Results.
	Grams.	Ozs.	Min. Min.	Max. Min.		
Mar. 16..	75	2.64	30	30	1	Tree in full bloom May 6. No injury traceable to gas. Pl. XV.
Apr. 8..	75	2.64	30	60	2	One tree, not badly infested, treated 60 minutes without injury. The other tree treated but 30 minutes, on Apr. 28 showed bu ls on badly infested branches to be weak, but on May 13 appeared in good condition.
Apr. 12..	75	2.64	30	30	2	Buds expanding when treated. On May 6 trees have but few branches with terminal and lateral buds killed; and on May 13 they show but one-tenth full bloom.
Apr. 13..	75	2.64	30	60	7	May 6, some branches on all these trees show terminal and lateral buds injured; one tree treated one hour injured more than the others. (See Plate XVI.) May 13, less than one-tenth full bloom.
Total number treated with 75 grams					12	

TABLE VI.—JAPAN WALNUT TREES TREATED UNDER FUMIGATORS, 1901.

Date.	Amt. of KCN per 100 cu. ft.		Time treated.		No. of trees.	Results.
	Grams	Ozs	Min. Min.	Max. Min.	Min.	
Mar. 19..	15	.53	35	35	1	Tree badly infested. No injury.
Mar. 16..	20	.70	30	45	7	No injury.
Mar. 18..	20	.70	30	65	8	No injury.
Mar. 16..	25	.88	40	45	2	No injury.
Apr. 5..	25	.88	30	45	4	No injury.
Apr. 8..	25	.88	30	30	1	No injury.
Apr. 9..	25	.88	30	35	4	No injury.
Apr. 12..	25	.88	30	30	1	No injury.
Apr. 13..	25	.88	30	30	4	No injury.
Mar. 18..	37.5	1.32	30	30	1	No injury.
Apr. 17..	75	2.64	30	30	1	May 6, all terminal buds killed. June 10, tree has developed latent buds and is in full leafage, showing tendency to form numerous branches but no leaders. All other walnuts uninjured.

From the data in these tables it appears: (1) That it is unsafe to leave peach trees exposed to the action of the gas for periods of 12 hours no matter what weight of potassium cyanide per cubic foot is used; (2) that all vigorous trees, even those as tender as peach can be safely treated with as much as $2\frac{1}{2}$ ozs. of 98 per ct. potassium cyanide per 100 cu. ft. (.75 grm. per cu. ft.) for a period not exceeding 30 minutes, providing the treatment is given while the trees are dormant; (3) that peach trees which have their vitality reduced by attacks of the scale are liable to be injured after April 1st by use of $2\frac{1}{2}$ ozs. of potassium cyanide per 100 cu. ft.; but the injury is not usually such that the trees do not recover and make a better growth than while infested; (4) that peach can be treated in the orchard for intervals varying from 30 to 60 minutes with as much as $1\frac{3}{4}$ ozs. potassium cyanide per 100 cu. ft. (.50 grms. per cu. ft.), even after fruit buds show color; (5) that walnut and chestnut will stand the same treatment as peach.

The tests made in 1900, under tents and hence liable to error, indicate that plums and cherries are similar to peach in resistance, and that pears cannot stand $1\frac{3}{4}$ ozs. of potassium cyanide after the flower buds are exposed. At this time the injury was confined principally to the flower buds, but even where these were injured the entire setting of fruit was not destroyed.

Johnson has reported injury to peach in Maryland by use of about one-half the above amounts of potassium cyanide per cubic foot. It will be shown under rules for estimating contents of tents and fumigators that, through an error, Johnson has actually used much more than the amount he recommends as safe.

CAUTION.—It should be remembered that the larger amounts tested apply only to trees in orchards where the gas comes in contact with the ground.

EFFECT OF THE GAS ON THE SCALE-INSECT.

The effect of the gas upon the insects is not as easy to determine as its effect on the trees. Frequently on branches thoroughly encrusted with this pest not over one per ct. of the

individual specimens will be alive. Again, the percentage of living scale-insects will vary not only on the part of the tree upon which they occur but also with the season of the year.

CONDITION BEFORE TREATMENT.

The following table gives approximately the condition of the San José scale-insect on peach in March, 1901, prior to treatment. The percentages were obtained by taking the infested branches into the laboratory and making a microscopic examination of all the specimens. The branches were taken from different trees:

TABLE VII.—SAN JOSE SCALE ON PEACH, MARCH, 1901.

	1-yr. wood. *Per ct.*	2 yr. wood. *Per ct.*	Average. *Per ct.*
Living specimens on first branch.......	24.	52.	38.
Living specimens on second branch....	27.	62.	44.5
Living specimens on third branch......	22.	65.	43.5
Average	24.3	59.6	42.

CONDITION AFTER TREATMENT.

Under tents.—(1) In the small orchard, November 20, 1900, four plums showed a few living specimens of the scale-insects on new wood. Three of the trees were badly infested before treatment; on the other, specimens were numerous at time of treatment. These trees were fumigated April 13th. As near as could be estimated for tents, 1¾ to 2 ozs. of potassium cyanide per 100 cu. ft. were used for periods varying from 35 to 60 minutes. One cherry, treated April 14th with over 2 ozs. per 100 cu. ft. for 70 minutes has living specimens on new wood. Specimens were numerous before treatment.

It is a marked fact that as late as December 7, 1901, the increase of specimens on the above trees has been so slow that it is still a hard matter to find them.

(2) In the large orchard, living specimens of the insects were found on treated trees in one instance, but as only part of the orchard was treated there was a chance for the insects to be transferred from untreated to treated trees thus making it im-

possible to determine whether the specimens found had survived the fumigation.

Under folding fumigators.—Five hundred and fifty tests were made during the winter of 1900-1901. At time of treatment many of these trees were infested. Only one was found where there was positive proof that the scale had survived the fumigation; this was a peach treated March 19th (a windy day), with four-fifths ounce of potassium cyanide per 100 cu. ft. (.25 gram per cu. ft.) for 35 minutes. On August 26th, it was found that the lower branches which lay close to the ground were badly infested with living specimens. Adjoining trees showed a few living scales on December 7th. These were not badly infested trees before treatment, and the specimens were found only on sides next the previously infested tree showing quite conclusively that they became infested from it.

In only one other instance has any trace of living scale shown itself as late as December 7th. This was on a tree which was slightly if at all infested before fumigated. Only three specimens were found. All indications are that this tree became infested after treatment, possibly from the previously mentioned tree, although about ten rods to the north of the latter.

As shown in the discussion of diffusion, it is possible that hydrocyanic acid gas was absorbed by the moist ground rapidly enough so that individual scales on the lower branches survived the treatment, but if this was the case similar results ought to have been obtained from some of the other 181 tests made on peach with same amounts of cyanide of potassium, even though all the trees were not infested at time of treatment. It seems more probable that an accident during fumigation of this one tree must have occurred. Either the wind caused the fumigator to lift frequently during the period of exposure, or an error was made in the amount of chemicals used.

Before drawing conclusions it should be stated that the plums found infested after treatment were fumigated after the tents were much the worse for wear and badly in need of reoiling. In fact, at time of treatment of this small orchard there was

always a marked odor of hydrocyanic acid gas to the leeward of the trees. Hence conclusions as to what can be accomplished by fumigation with the above gas should not be based upon results obtained with tents.

CONCLUSIONS.

Excluding conditions where tents were used, the results of tests for 1900-1901 show that with good covers, debarring accidents and infestation from other sources, fumigation with hydrocyanic acid gas can be depended upon to exterminate the San José scale, on medium sized orchard trees, over small areas.

Under favorable conditions, the scales were all killed by the use of .15 gram per cu. ft. (one-half ounce of potassium cyanide per 100 cu. ft.), but as shown later, at least double this amount should be used unless the operator is certain that all conditions *are* favorable.

AMOUNT AND GRADE OF CHEMICALS TO USE.

Writers on fumigation with hydrocyanic acid gas have recommended the use of various formulas. The principal variations are in the amounts of acid and water used. Coquillet,[1] Marlatt[2] and Webster[3] have recommended the use of one part by weight of potassium cyanide, one part by volume of sulphuric acid, and two parts by volume of water. Based on the weight of potassium cyanide, the charge would be represented by the formula 1–1–2. Smith[4] recommends a formula of 1–1–3. Johnson[5] and Gould[6] have recommended the use of 1–1½–2¼; while Craw[7] recommends 1–1¼–3. The author has recommended the use of 1–1⅓–4. The latter was based on results obtained in all-night treatment of forcing houses and in nursery fumigation, where

[1] *Insect Life*, 2:203 (1890).

[2] Year Book U. S. Dept. Agr. 1896:228.

[3] Ohio Agr. Exp. Sta. Bul. 103 (1899).

[4] Rept. N. J. Agr. Coll. Exp. Sta., 1897:467.

[5] Md. Exp. Sta. Bul. 57:79 (1898).

[6] Md. Exp. Sta. Bul. 73:163 (1901).

[7] Fourth Rept. St. Board Hort. Cal. 1894:107.

the gas was allowed to act for several hours, the excess of water being essential to prevent crystallization of by-product.

The following tables show tests made in orchard fumigation under box fumigators, hence should show approximately the amounts of acid and water to be used to give most uniform results within shortest period of time under varying field conditions.

The potassium cyanide used was what is known by dealers as "broken cyanide 98 per ct. pure" and unless so stated no additional labor or cost was expended in order to have it of a definite size. Except where indicated, chemically pure sulphuric acid (98 per ct., sp. gr. by test 1.84) was used.

Table IX.—Tests with Various Formulas for Fumigation.

KCN.	H_2SO_4.	H_2O.	Time of treat-ment.	Time of chem. action.	Results.
Ozs.	*Fl. ozs.*	*Fl. ozs.*	*Min.*	*Min.*	
					FORMULA 1–1–2.
7.0	7.0	14.0	35.0	11.0	KCN in two pieces. By-product crystallized in 30 min. Temp. 53.5.
7.0	7.0	14.0	35.0	10.0	KCN in two pieces. By-product crystallized, commercial sulphuric acid.
7.0	7.0	14.0	30.0	17.0	KCN in one piece. By-product crystallized, commercial sulphuric acid.
7.0	7.0	14.0	35.0	11.0	KCN in two pieces, one large, one small. Temp. 45°.
7.0	7.0	14.0	30.0	5.5	KCN powdered. Temp. 45°.
					FORMULA 1-1-3.
4.0	4.0	12.0	30.0	*	Chem. action not complete, com. acid.
6.0	6.0	18.0	35.0		Chem. action not complete, com. acid.
8.0	8.0	24.0	25.0		Chem. action not complete, com. acid.
15.0	15.0	45.0	35.0		Chem. action not complete, com. acid. some large pieces of KCN.
6.5	6.5	19.5	30.0		Chem. action not complete, com. acid.
11.25	11.25	35.0	30		Chem. action not complete, com. acid. some large pieces of KCN.
4.5	4.5	14.0	30.0		Chem. action complete, com. acid.
4.5	4.5	14.0	30.0		Chem. action complete, com. acid.
7.0	7.0	21.0	35.0	11.5	Chem. action complete, one piece KCN.
11.25	11.25	35.0	60.0		Chem. action complete, com. acid.
					FORMULA 1–1⅛–3½.
11.25	13.0	39.0	30.0	8.0	KCN in two pieces. Com. acid.

* In cases where time of chemical action is not given, the tests were made under tents where the action could not be observed.

FORMULA 1–1¼–1¼.

KCN.	H_2SO_4.	H_2O.	Time treated.	Time chem. action.	Results.
Ozs.	*Fl ozs.*	*Fl ozs.*	*Min.*	*Min.*	
7.0	8.75	8.75	30.0	16.0	KCN in several pieces. Chemical action very slow, considerable brown sediment. Com. acid.
					FORMULA 1–1¼–2½.
7.0	8.75	17.5	35.0	5.0	KCN powdered, action violent enough to throw contents out of generator. By-product crystallized in 1 hour. Com. acid.
7.0	8.75	17.5	35.0	5.5	Conditions and results same as above, chemically pure acid.
7.0	8.75	17.5	35.0	4.0	Conditions and results same as above.
7.0	9.0	18.0	35.0	6.5	KCN no larger than hickory nuts, no crystallization.
7.0	9.0	18.0	35.0	10.0	KCN in one piece. No crystals.
					FORMULA 1–1¼–3⅛.
11.25	14.0	36.0	30.0	6.0	Com. acid.
11.25	14.0	36.0	30.0	8.0	Com. acid.
11.25	14.0	36.0	30.0		Chem. action complete, com. acid.
11.25	14.0	36.0	30.0		Chem. action complete, com. acid.
11.25	14.0	36.0	30.0		Chem. action complete, com. acid.
					FORMULA 1–1¼–3¾.
4.0	5.0	15.0	30.0		Chem. action complete, com. acid.
4.0	5.0	15.0	40.0		Chem. action complete, com. acid.
4.0	5.0	16.0	40.0		Chem. action complete, com. acid.
7.0	8.75	26.25	35.0	7.0	KCN in one piece, chem. pure acid.
7.0	8.75	26.25	30.0	7.5	KCN in two pieces, chem. pure acid
7.0	8.75	26.25	30.0	3.0	KCN powdered, chem. pure acid.
12.0	15.0	45.0	30.0	12.0	
					FORMULA 1—1½—3.
7.0	10.5	21.0	30.0	4.0	KCN powdered, action violent enough to throw contents out of generator.
7.0	10.5	21.0	35.0	6.0	KCN in one piece. First period of action uniform.
7.0	10.5	21.0	35.0	6.0	KCN in one piece. First period of action uniform.
					FORMULA 1–1½–4½.
7.0	10.5	31.5	35.	9.0	KCN in one piece.

These tables show that where large pieces of potassium cyanide were used in the formula 1–1–2, the action was too slow and the by-product crystallized within a short time. In some

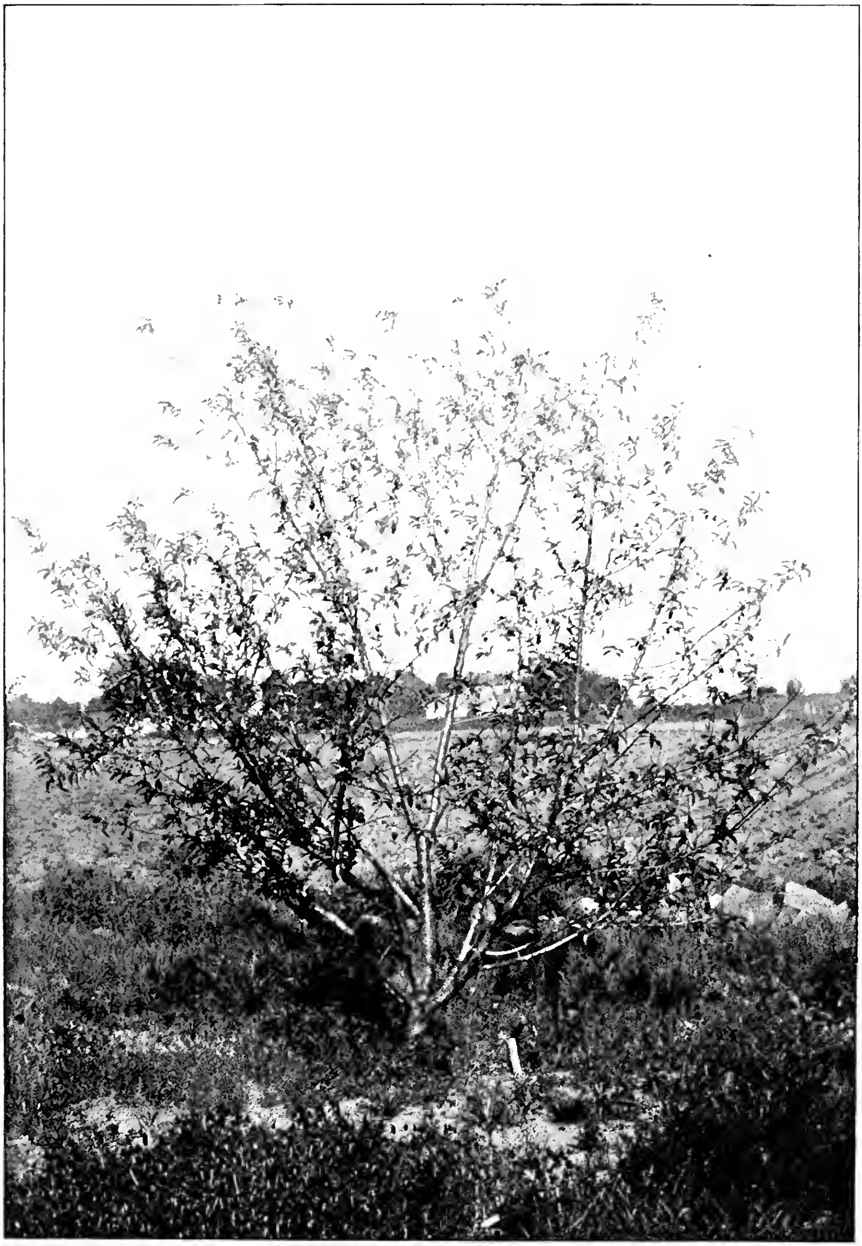


Plate XV.—Peach Tree Fumigated March 16, for 30 Minutes, with 0.75 gram of 98 per ct. Potassium Cyanide per Cubic Foot.

(Photographed May 24.)

PLATE XVI.—PEACH TREE TREATED SAME AS ONE IN PLATE XV, ON APRIL 13.
(Photographed May 24.)

Plate XVII.—Method of Handling 30-Foot Tents, and Protecting Trees by Means of Iron Bows.

Plate XVIII. Transferring Fumigator from one Tree to Another.

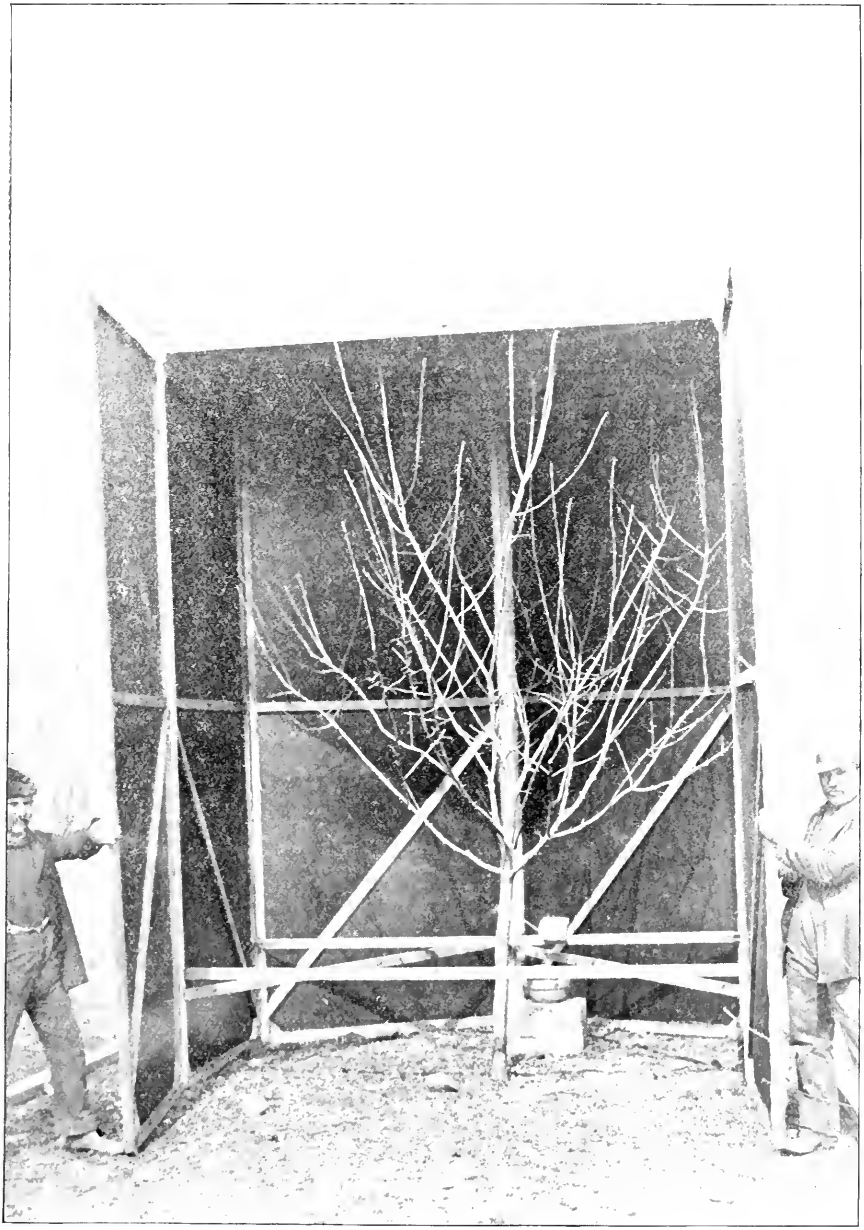


Plate XIX.—Fumigator around Tree, Ready for Closing.

PLATE XX.—METHOD OF CLOSING FUMIGATOR.

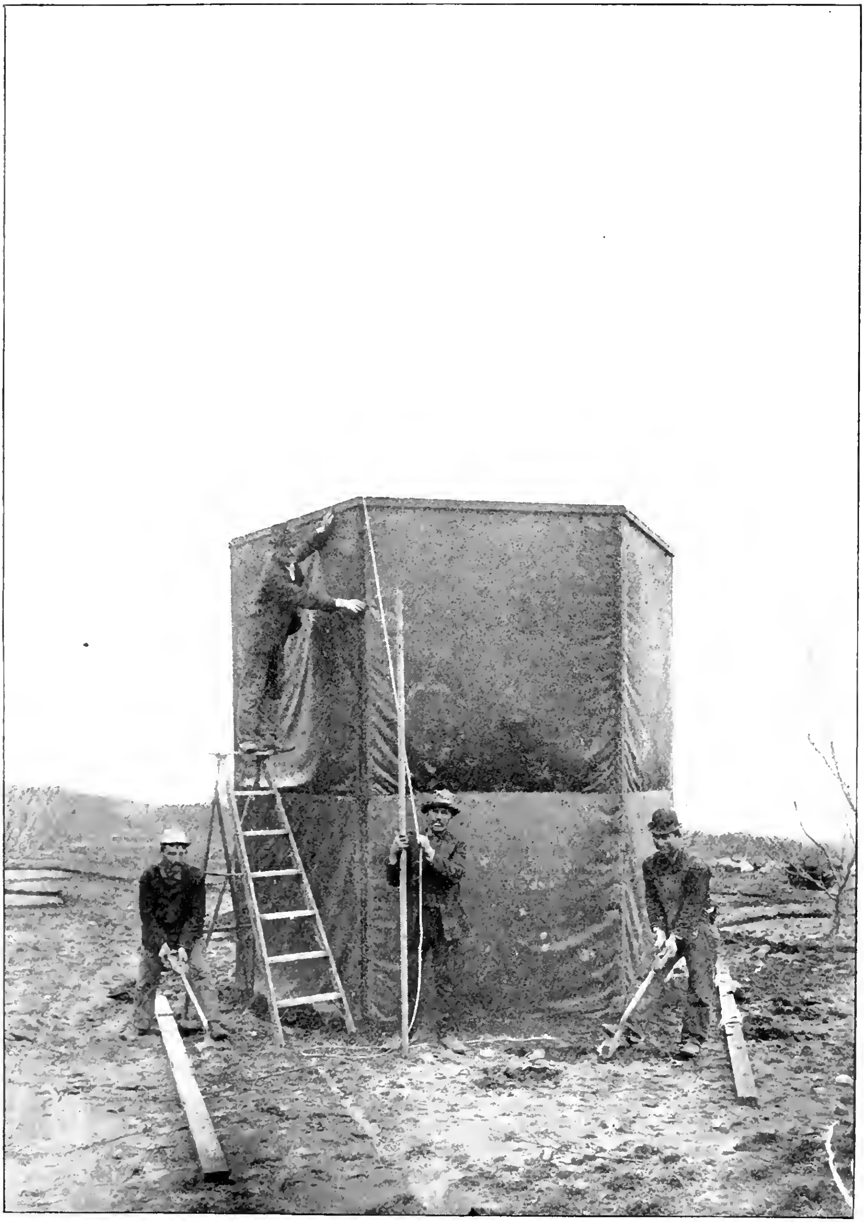


Plate XXI.—Fumigator Closed, Ready for Dumping Charge.

Plate XXII.—Folding Fumigators in Operation.

cases the latter interfered with rapid emptying and refilling of generators. Where the chemicals were used in the proportion of 1–1–3, the action was entirely too slow on the ordinary size of broken cyanide. In some instances it was not even complete in the period allowed for fumigation of a tree.

The use of equal amounts of acid and water, even though greater than the amount of potassium cyanide, did not give increased chemical action.

The use of an excess of acid and three times as much water did not materially decrease the rate of chemical action.

In general the table shows that a slight excess of acid and two to four times as much water gave fairly good results, but in cases where powdered potassium cyanide was used the chemical action was violent enough to throw the contents out of the generator.

CONCLUSION.

It should be observed that the smaller the pieces of potassium cyanide the less time required for chemical action, no matter what ratio of acid and water was used. By the use of one and a half times as much acid and three times as much water as of potassium cyanide, by volume, the action was nearly as rapid with large pieces as with small pieces when used with less acid and water.

Where large quantities of potassium cyanide are broken fine there is a waste not only by decomposition on exposure to the air but also by its being thrown out of the generator when chemical action begins. Having it broken to a definite size, as some have recommended means an additional expense of 2 cents per lb. on wholesale price, but by using the finely broken potassium cyanide and an equal amount of sulphuric acid by volume the total cost per charge of chemicals is the same as where ordinary broken cyanide is used with one and a half times as much sulphuric acid by volume. Hence the principal gain in using the ordinary broken potassium cyanide of the trade and a larger amount of sulphuric acid is prevention of waste; at the

same time uniform chemical action is obtained and spattering avoided.

Although the tests indicate that a formula of 1–1½–3, that is 1 part by weight of KCN, 1½ times as much acid and 3 times as much water by volume as of KCN, gave best reactions, the formula generally recommended for orchard and nursery work, viz.: 1–1½–2¼, that is 1 part by weight of KCN, 1½ times as much acid by volume and 1½ times as much water as acid gave as good results under most conditions, hence if preferred can be followed. If too violent action results more water can be added.

ABSORPTION OF THE GAS.

From results obtained in fumigation of forcing houses, we were led to assume that the hydrocyanic acid gas either had a tendency to bank or was rapidly absorbed as it came in contact with moist soil.

Some tests made during winter of 1899 and the following winter on diffusion of gas showed that about 50 per ct. of the gas was absorbed by the moist earth. These tests also showed that under cloth-covered fumigators the diffusion was quite uniform.

Penny[1] has shown that in the presence of moist soil over 50 per ct. of the available gas present in a cubic foot of space is absorbed. For example, if .15 grm., an amount recommended for fumigation of nursery stock in closed boxes, is used in orchard work where it comes in contact with moist earth, only .075 grm. of this amount becomes available for killing the scale-insects.

These conditions, together with failure, in some cases, to kill all the scale-insects on low branches and at base of trees, indicate that double the amounts of KCN generally recommended for fumigation of nursery stock should be used in orchard work, at least if complete extermination is the object sought. The foregoing tests show that on fairly vigorous orchard trees no injury to tree will result from use of this increased amount of

[1] Del. Coll. Agr. Exp. Sta. 12th Ann. Rept. p. 229.

KCN. Whether the additional expense required will warrant the use of this amount should be decided by the operator, and in many cases he can even decide from the condition of the trees whether it is necessary to use a heavy charge.

APPARATUS.

TENTS.

During 1899–1900 two sizes of sheet tents were made and tested for orchard fumigation. Two twenty-foot and two thirty-foot tents were constructed at a cost of $15 and $25 apiece for the two sizes, by the Richard Fitzgerald Water Proof Co., 38 South street, New York city, on the following plan: Each tent was octagonal in shape, the seams all running to a common centre, which was strengthened by sewing on an extra piece six feet square. A quarter-inch rope was hemmed in to reënforce the bottom.

After making, the tents were dipped in a mixture of linseed oil and lampblack combined with some substance that kept them pliable when dry. One large tent was of heavy drill, the other large tent and the two small tents were made of sheeting.

To protect the trees from injury by the tents and at same time to prevent tearing the tents with broken branches, U shaped bows were made of iron pipe and used over the trees. It was thought these bows would not only protect the trees but be an aid in sliding the tent on and off the tree, as well as give a uniform size and shape to the enclosed space. Three sizes of the piping were tested, viz., one-fourth, three-eighth and one-half inch. The first proved worthless, the three-eighths answered for the small tents, while the one-half inch answered for all purposes. Three of these bows were required over each tree, and in order to manipulate four tents to advantage, six sets of three each were necessary. The additional cost of the bows brought the cost of the outfit to $26 and $39 each, for small and large tents, respectively.

A method of manipulating the tents and the arrangement of the bows or arches are shown in Plate XVII. With a little care

in setting, these bows furnished approximately the same amount of space for each tree, no matter what the size and shape, thus making it unnecessary to calculate the amount of chemicals that must be used for each, and at the same time prevented breaking branches and rubbing the buds from them. The extra labor of handling combined with their expense would forbid their use except in special cases. The small gain in form, and the slight advantage acquired by their use for getting a tent on and off a tree was too small to be considered. They could not be used on frozen ground as it was necessary to sink them into the ground one and one-half to two feet.

Tents made over thirty feet in diameter require special apparatus for handling, which adds to the expense of the outfit. In addition large tents increase rapidly in cost compared to size. Forty-foot tents cost between $45 and $50, when made to order.

BOX FUMIGATORS.

PREVIOUSLY DESCRIBED FORMS.

One style of box fumigator, with the method of using and its advantages, has been described by V. H. Lowe in Bul. No. 181 of this Station, hence need not be described at this time.

The only other form of covering for orchard fumigation that has been described and is being used at present time, which is not simply a variation of the octagonal tent, is the Emory fumigator designed and described by Prof. W. G. Johnson.[1] This a half-box, half-tent affair for which it is just as difficult to estimate cubic contents as for a tent; furthermore it is more unwieldly than a tent.

At first Johnson[2] claimed that his fumigator could be built for $12. An attempt was made in 1899 to purchase a set of these fumigators. The price asked was $35 each. In a later publication[3] Johnson puts the cost of construction at $30 apiece.

---

[1] U. S. Dept. Agr. Div. Ent. Bul. No. 20, n. s., pp. 43–45, 1899.

[2] l. c.

[3] *Rural New-Yorker*, Jan. 20, 1900.

A HEXAGONAL FOLDING FUMIGATOR.

During the winter of 1900–1901, a folding hexagonal fumigator was constructed and tested.

In building this fumigator an effort was made to shun most of the disadvantages met with in using a tent.

The box designed and used by Lowe overcomes the disadvantages of a tent but has considerable waste space and is an unwieldly piece of apparatus to store or move any great distance. The folding fumigator was constructed with the idea of having a gas-tight box of constant capacity, with as little waste space as possible compared with its size, which could be taken down and folded, if desirable, stored in small space, or conveniently transported from one place to another. Like Lowe's square box, this hexagonal fumigator can be placed around a tree instead of having to be lifted over it by means of a derrick, a disadvantage of the Emory fumigator.

Frame.—Two sizes of this fumigator were built, one eleven and one-half and the other twelve feet high. In form they were hexagonal, the shortest diameter being eight and one-half and ten feet respectively, for small and large size. Each side of the frame was made separately and formed a rectangular figure 6 x 12 ft. in the larger and 5 x $11\frac{1}{2}$ ft. in the smaller. The stiles, vertical strips, of each side were made by ripping nine-inch undressed spruce boards into four pieces. By making the two outer cuts on each board at diagonal the rails were beveled on one edge at an angle of 60°. (See Fig. 4, Plate XXIV). The latter was necessary in order to have each side stand at the proper angle. Hence the stiles were $2\frac{1}{2}$ inches wide on the outside, $1\frac{3}{4}$ inches on the inside, and $1\frac{1}{4}$ inches thick. The top and bottom rails and horizontal brace were of the same material, $1\frac{1}{4}$ x $2\frac{3}{4}$ inches. The diagonal braces were made of 1 x 2 inch stuff. Instead of being mortised the stiles and rails were mitered and firmly nailed. To give additional strength a triangular block was nailed into each corner. The horizontal brace was placed above the center and a diagonal brace below

the horizontal one. This was done to bring all weight as near the base as possible. See Plate XXIII.

The separate sides were hinged together in pairs, the hinges being placed outside; after which two pairs were hinged to the third, the hinges being placed inside. This allowed of the folding of the sides back and forth on one-another so that the whole when closed occupied no more surface space than did one rectangular side. It also permitted of the front being opened as a double door to a width equal to the shortest diameter of the box. Two pairs of 4-inch backflap hinges were required on each pair of sides and also for fastening the pairs together.

The top was constructed in three parts, one rectangular and two triangular frames. Except in length and braces the center or rectangular portion of top was made the same as one of the sides. At first it was only braced by means of two diagonal braces; later a triangular cross-brace was added. See Fig. 2, Plate XXIV. This not only prevented sagging of the cover but raised it so that water would run off; at the same time it formed The remaining parts of the top frame-work consist of two isosceles triangles, the two equal sides of which were of the same length as the width of one side of the fumigator. These triangles were hinged to the rectangular piece. By nailing a 1x3 inch rail around outside the top frame and tacking a small cleat on the lower face of this frame, a one-and-a-half inch groove one inch deep was formed which fitted top rail of the side frames. See Fig. 3, Plate XXIV. Hooks and eyes were used to fasten the top to the side frames and also to secure the doors.

This top not only held the frame in shape, but so braced the upper portion that it was only necessary to use a few cross braces near the base to make the whole rigid. The arrangement of these cross braces is shown in Fig. 3, Plate XXIV. They were made of 1 x 2 inch spruce held in place by means of eight-inch shutter hinges. The latter allowed of the braces being removed when the fumigator was folded. They also allowed of the removal of the front brace when placing the fumigator around a tree.

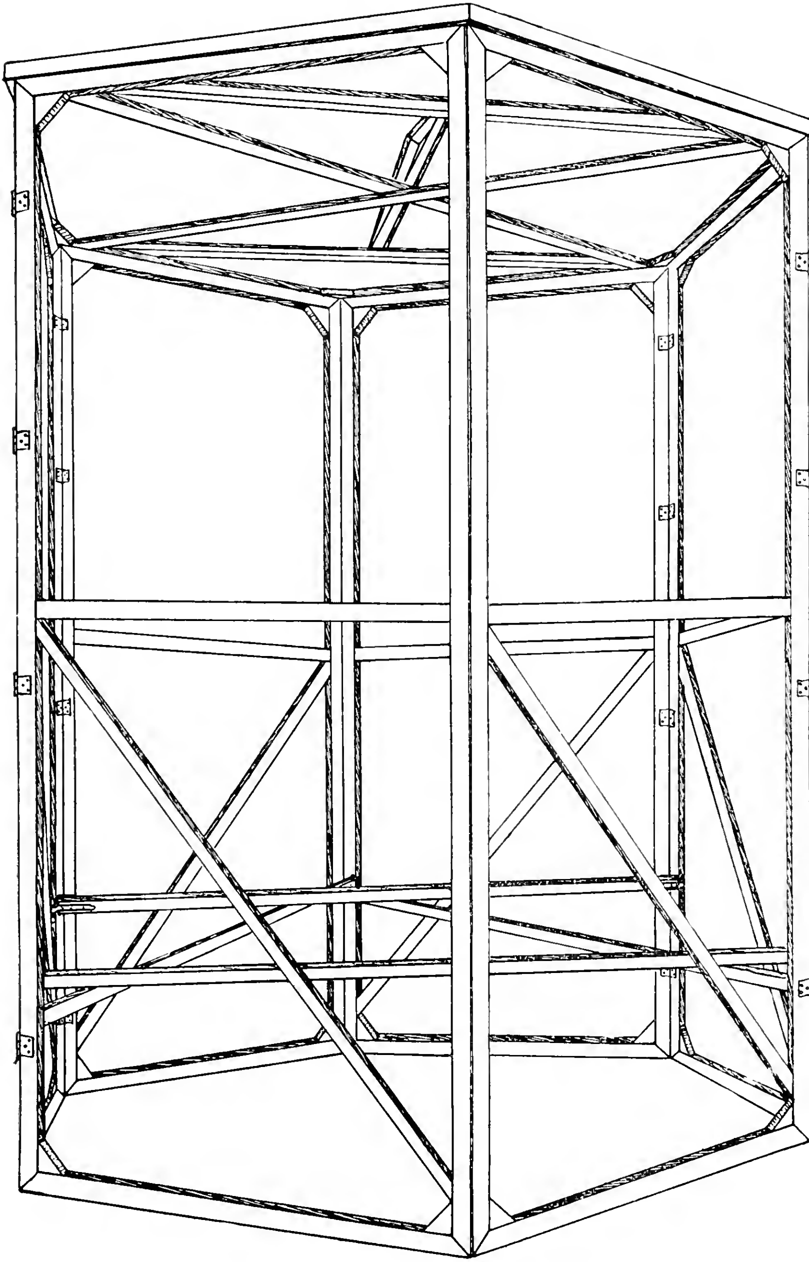


Plate XXIII.—Framework of Hexagonal Folding Fumigator.

Cover.—In all cases unbleached sheeting was used for covering the frames. In order to have as few seams as possible nine-quarter cloth was used on the twelve-foot and eight-quarter on the eleven-and-a-half foot fumigators. These widths required but one horizontal seam, which in most cases followed the middle rail; they also permitted of an over-lap on the top-rail. For allowing an over-lap on the stile of each door and a slack on two of the hinged angles, to prevent binding when closed, twenty-four-and-a-half and twenty-and-a-half yards in length of the above sizes were used for the sides of the two sizes of fumigators.

Before attaching cover, all the stiles and top rails of the frame were faced with strips of Canton flannel. This not only strengthened the hinged angles and increased the packing surface for doors and top-joints, but also prevented wearing of the cover on the rough frame-work.

By using three pieces of the sheeting, each a few inches longer and wider than the middle section of the top-frame, two top covers were made as follows: First, one piece was cut lengthwise into two strips of equal width. Each strip was folded on itself and the ends sewed together after which it was cut across diagonally forming two triangles. These were sewed to the sides of one of the remaining rectangular pieces completing the cover. In a similar manner the other strip was made into two triangles, sewed to the third rectangular piece and formed a second cover.

When complete the cover was first fastened to bottom rail of frame and then stretched to top rail and tacked. In each case allowance was made for folds on angles where necessary, and excessive horizontal stretching avoided.

The only difficulty in attaching cover to top-frame was on the four angles of the sides. Here a gore had to be inserted to allow opening of the top.

Two grades of sheeting were tested, "Lockwood" nine-quarter wide costing 15¾c, and "Palma" eight-quarter wide at 17½c per yard. The latter had a firmer thread and was woven more

closely than the "Lockwood;" as a result it required less oil in filling. Undoubtedly a grade of sheeting known as "Utica" costing $20\frac{3}{4}$c per yard for nine-quarter goods would have been better than "Palma" but this would have made the fumigator nearly as heavy as if covered with duck.

Filler.—After fastening cover to frame it was painted with the following mixture: Raw linseed oil 5 gal., lampblack, ground in oil, 1 lb., melted beeswax $\frac{1}{2}$ lb. Two coats of filler were required on Palma and three on Lockwood.

To make all joints air-tight the edge of each door and the groove of the top-frame were lined with double faced Canton flannel. To avoid glazing, the Canton flannel should be put on after oiling. Felt was tested for the above purpose but cost more, was not as easily fitted, did not stay in place as well, nor wear as long as Canton flannel.

Cyanide holders.—On the rear cross brace of each fumigator a cigar-box with one end removed was rigged for holding the charge of potassium cyanide. See c, Fig. 3, Plate XXIV. A string passing through a very small hole in one of the rear vertical rails was attached to the box in such a manner that when released the contents were dumped into the generator. Earthenware stew-kettles holding from one to two gallons were used as generators.

Attachments.—For handling a fumigator four open-bar staples were used, one being attached to each side corner. These were put on with stove bolts and were easily removed when fumigator was folded. By placing sixteen-foot scantlings under the staples, four men, with a little practice, could easily move a 10 x 12 foot fumigator. See Plate XVIII.

Large leather washers were used where all hook and eye screws went through the cover, and leather facings were used under the staples.

At first a sod-cloth or flap was attached around base of fumigator for banking upon in same manner as with tents. This proved to be of slight advantage except on very windy days when there was danger of the fumigator jumping. The soil

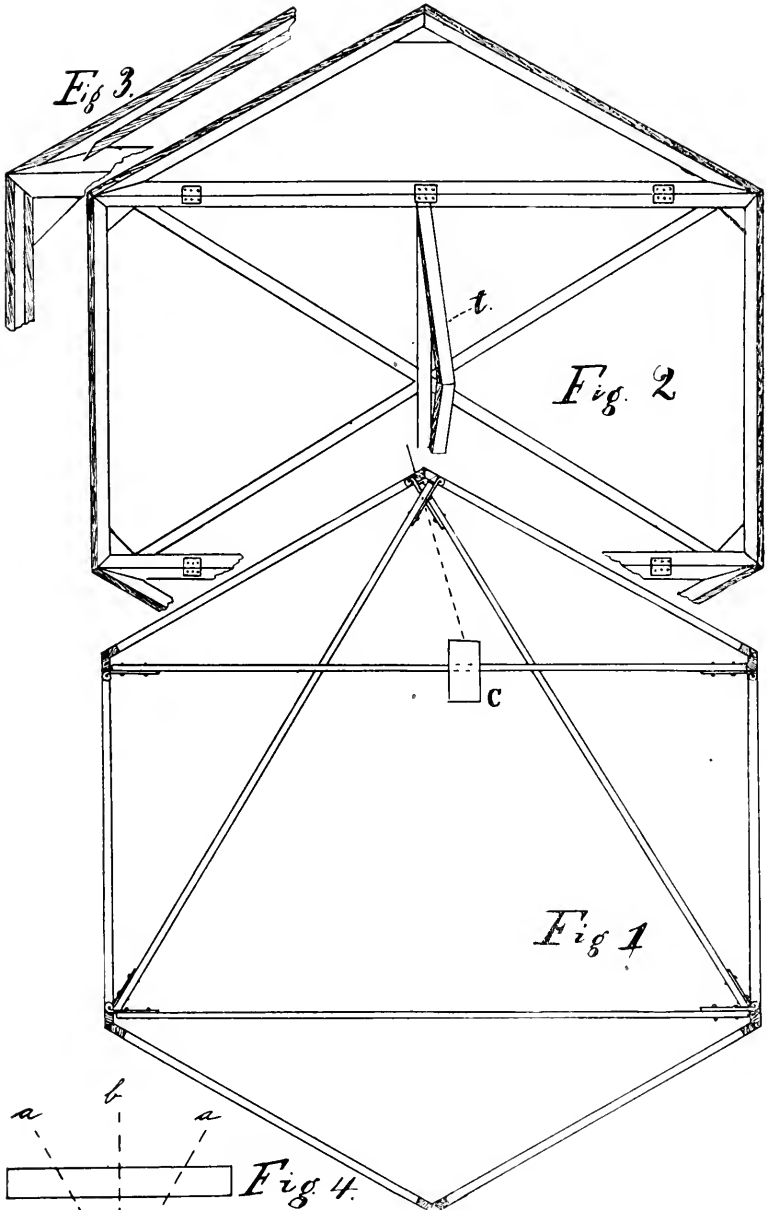


Plate XXIV.—Details of fumigator construction: 1, Form of fumigator and movable braces; C, cyanide holder; 2, method of hinging and arrangement of braces of top; t, triangular rest for lid and peak for cover; 3, underside of top, showing groove to fit frame; 4, method of ripping planks for stiles.

could be banked directly against the fumigator, making as close a joint as when placed upon the sod-cloth. As the latter proved to be very much in the way when moving the fumigator it was removed.

Cost.—The cost of building a twelve-foot fumigator, not including labor of putting on cover and oiling of same was $27, while the cost of the smaller size was $22.37; hence the entire cost of building such fumigators ought not to exceed $30 and $25 respectively.

Manipulation.—The method of using and handling the folding fumigator after treating a tree was as follows: First, the front lid of top was unhooked and turned back, the doors were opened next and the front brace removed. By having the open-bar staples placed at the proper height the poles used for carrying the fumigator rested upon the workmen's shoulders, allowing them one hand free for lifting branches or holding the doors open. See Plate XVIII. After placing the fumigator around a tree the charge of cyanide was placed in its receptacle, the generator being placed beneath the latter; next, the brace was replaced, the doors brought together, the lid closed and hooked, after which the doors were hooked and base of fumigator banked. See Plates XIX, XX and XXI.

A light pole for unfastening hooks and opening lid proved useful. With the aid of an anchor rope the same pole proved handy for closing the lid especially on the twelve-foot fumigators.

Whenever the wind was not too brisk and a fumigator had to be moved but a short distance it was found unnecessary to use the front brace. By the use of all braces and the addition of anchor ropes the folding fumigators could be used on days when the wind was too heavy for handling tents; they could also be anchored and left standing in an orchard over night.

With a set of four folding fumigators and five men, forty trees could be fumigated in a day. In no case was the time of exposure less than thirty minutes and in most cases it exceeded forty-five minutes. With the four fumigators there were

periods in which sets of trees were covered, fumigated and uncovered in forty minutes. At this rate it was estimated that with the same number of men and six fumigators ninety trees could have been fumigated in ten hours. Possibly with a set of twelve fumigators one operator with a crew of eight men might have fumigated one hundred and fifty to one hundred and eighty trees in ten hours, but in no case would it be possible for them to fumigate two hundred trees in the same time.

Advantages.—The principal advantages of this style of fumigator lie in the fact that it is of constant capacity so that the operator does not need to guess at size of trees and vary the amount of chemicals used for each; that it can be placed around a tree and not require a derrick to lift it over the same, as is the case with tents and the Emory fumigator; that it contains a minimum amount of waste space compared to its size, and can be stored in comparatively small space. In addition it has the advantage of rarely breaking the trees or rubbing off the buds.

ESTIMATING CONTENTS OF TENTS OVER TREES.

The method usually followed in California has been to estimate the height of a tree and diameter through the foliage, and from this the amounts of chemicals to be used are determined by tables previously computed. Johnson[1] has given a similar table but there is an error in his method of estimating the cubic contents of tented trees with the result that the amounts given in the table are in most cases nearly double what they should be, providing he intended to use but .20 gram potassium cyanide per cubic foot as stated. The amounts given in table show that about .40 gram per cu. ft. was used. He gives the following rule for estimating contents: "First, I calculated the contents of a cylinder whose height and diameter are the height and diameter of the tree, then calculated the contents of a sphere whose diameter is the height of the tree. Then by taking half the difference and adding it to the contents of the cylinder, I

[1] Md. Agr. Exp. Sta. Bul. 57, p. 79.

found my estimation was approximately correct." The diameters given in table indicate that the measurements were taken through the widest portion of the tree. Now a cylinder whose height is the same as the height of a given tree and its diameter the diameter of the tree through the widest portion, surely contains more cubic space than could be included under a tent thrown over the same. Adding half the difference between a cylinder and a sphere, the height of one and the diameter of the other being the same as the height of the tree, to the contents of the cylinder, makes the contents of the tented tree much more than they should be.

All trees, no matter what their shape, when covered with a tent form approximately half a spheroid or ellipsoid, whose major axis is twice the height of the tree and minor axis the diameter of the tree through its widest portion. In most cases the contents of the tent will be slightly less than a hemispheroid of the same height and diameter. Hence we have the following rule which is accurate enough in actual field work: Multiply the height of the tented tree by the square of the diameter through the branches, and this product by the constant .5236. A more simple rule is to multiply the height of the tented tree by the square of the diameter and this by one-half the number of grams of potassium cyanide to be used per cubic foot. The product will be the total amount, in grams of potassium cyanide required for each tree. To reduce this to ounces divide by 28.35. This rule applies only to tented trees.

Although in itself the foregoing rule is simple, its application is not so easy. It is not an easy matter to estimate the dimensions of a tented tree and much depends upon the skill of the operator in fixing the size.

Most tables are intended as a guide for guessing at the contents of a tented tree, although some writers have failed to state whether measurements should be made before or after tenting the tree.

ESTIMATING CONTENTS OF BOX FUMIGATORS.

The cubic contents of rectangular boxes are easily computed. To estimate the contents of a hexagonal fumigator, multiply the width of one side by one-quarter of the shortest diameter, and this product by the number of sides and by the height; this will give the cubic contents.

COMPARISON OF VARIOUS FUMIGATORS.

Tents.—The principal advantages of tents for orchard fumigation are that they require less chemicals and have less waste space than any other form of covering, and that they can be easily folded for storing or for transportation from one place to another. Their objectionable features lie in the facts that the space enclosed by them cannot be accurately estimated; that this space and the amount of chemicals must be determined for each tree; and that they rest directly upon the tree and are liable not only to break the branches but to rub off many of the buds. Furthermore, they are apt to be torn by the broken branches, which, with constant abrasion in folding, causes them to leak. The result is that there is no certainty as to the thoroughness of the work done. When made over 30 feet in diameter they not only require a derrick for handling, but increase rapidly in cost. In addition, an expert is required where tents are used, to estimate contents.

Box fumigators.—Box fumigators[1] whether folding, opened by removal of one side or lifted bodily over a tree, have the advantage of constant dimensions, hence the amount of chemicals for charging can be accurately estimated and need be determined but once for all. They have the further advantage of not resting upon the tree, thus they rarely break the branches or rub buds from them; they are not as apt to be torn, therefore give more uniform results and last longer; they have the disadvantage of requiring more chemicals than do tents, they are more unwieldy to handle, store or move from one orchard to another.

[1]This does not include Johnson's "Emory fumigator."

The hexagonal folding fumigator has an advantage over all other forms of so called box fumigators in, that it contains the least amount of waste space, and that it can be folded into small compass for transportation or storage.

For fumigation of deciduous trees over ten and under sixteen feet in height hexagonal folding fumigators can be constructed and handled at less cost than can tents, but the additional expense for chemicals required by the folding fumigator would probably more than counterbalance the difference.

All forms of covers used in orchard fumigation have a disadvantage in that there is a limit to the size which can be handled. As yet no single cover has been devised for trees over 20 feet high. Marlatt[1] states that citrus trees 30 feet high are fumigated in California by using two sheets, one overlapping the other. (It should be noted that he describes the handling of these tents by means of 25-foot poles with tackle. It is a mechanical impossibility to use tackle of this size on trees over 25 feet high.) Lapping one sheet over the other and making a tight joint may be possible on citrus trees and thorough enough for " black scale," but could not be made to work on deciduous trees for San José scale.

It is not advised that any one attempt the building and handling of folding fumigators over 16 feet high and never more than 10 feet in diameter or with 6-foot sides. We believe that fumigators with 5 foot sides and 15 or 16 feet high can be handled as easily as the 12 foot fumigators with 6-foot sides. When constructed over 12 feet high spruce rails cannot be used for stiles.

COST OF FUMIGATION.

So many factors have to be taken into account in estimating the expense of fumigating trees in an orchard, that it is only possible to give an approximate estimate of cost. Even this must be conditioned not only by style of fumigating outfit used, but also by size and shape of tree to be fumigated as well as the

---

[1] Yearbook, U. S. Dept. Agr. 1896:229.

varying price of chemicals and the distance they have to be shipped.

Johnson states that chemicals cost from six to seven cents for trees 12 to 17 feet high. Apparently this estimate is based on pear trees.

By using a uniform charge of .25 gram of potassium cyanide per cubic foot and one and a half times as much acid by volume, the chemicals to fumigate a low-grown peach tree 10 feet high by means of a tent, in our work cost 10½ cents, while the chemicals for the same tree, when the 11½ foot folding fumigator was used, cost 15 cents.

With an outfit of four tents or four folding fumigators, the labor required to fumigate a tree cost 16 cents, making a total of 26½ and 31 cents per tree respectively. The expense of labor in each case is based upon the cost of one head operator and four helpers all employed by the day, also on condition that this force fumigate fifty trees in a day of ten hours, allowing 40 minutes for each tree. It was estimated that with an outfit of six tents or the same number of folding fumigators, the same force could fumigate 90 trees in a day, in which case the cost of labor per tree would have been reduced to 9 cents each, or a total of 19½ and 24 cents respectively for tents and fumigators.

The foregoing does not include cost of outfit. At a rough estimate six tents costing $150 could by patching and re-oiling be made to last long enough to fumigate one thousand trees. Hence the cost of outfit for each tree would be 15 cents making a total cost per tree of 34½ cents. (Chemicals 10½ cents, apparatus 15 cents and labor 9 cents.) The total cost per tree cannot be computed on same basis for folding fumigators, for with the same amount of patching and care in handling, the latter would last indefinitely.

As shown under "Absorption of Gas" it is best in orchard fumigation to use at least .30 gram of potassium cyanide per cubic foot of space, or about one ounce for every 100 cubic foot. The cost of chemicals will be proportionately increased, being about 12½ cents for tents and 18 cents for folding fumigators for trees 12 feet high.

REPORT

OF THE

Horticultural Department.

S. A. Beach, *Horticulturist.*

Heinrich Hasselbring,[1] *Assistant.*

N. O. Booth,[2] *Assistant.*

O. M. Taylor, *Foreman.*

Table of Contents.

[1] Resigned July 20, 1901.

[2] Appointed August 1, 1901.

STABLE MANURE AND NITROGENOUS CHEMICAL FERTILIZERS FOR FORCING LETTUCE.*

S. A. BEACH AND H. HASSELBRING.

SUMMARY.

In the experiments here reported nitrogenous commercial fertilizers were compared with each other as to their effect on the forcing of lettuce. The particular forms in which they were tested were dried blood, nitrate of soda, dried blood and nitrate of soda combined, and sulphate of ammonia. With each of these, acid phosphate and muriate of potash were used in quantities designed to exceed the needs of the crop.

The use of these commercial fertilizers without stable manure resulted in a decided increase in yield over crops on corresponding untreated soil but proved inadequate for forcing the lettuce in a sufficiently short time to be profitable. On the clay loam with no stable manure a better yield was generally obtained where nitrate of soda was used than where either sulphate of ammonia or dried blood was used. On the sandy soil the results with dried blood were generally superior to the results with the nitrate of soda or sulphate of ammonia. With sulphate of ammonia the results were very variable.

Dried blood combined with the smaller percentage of manure, gave, in the aggregate, better results than either nitrate of soda or sulphate of ammonia similarly combined.

The best crops were grown where the soil was fertilized with stable manure.

---

*Reprint of Bulletin No. 208.

Those portions of soil which received applications of 5 per ct. of manure in combination with the commercial fertilizers always showed a very great increase in yield over corresponding soils which were treated only with the commercial fertilizers. Further increase in the manure, however, was not followed by a corresponding increase in the yield.

When soils similar to those under test are used for the first time for forcing a crop of lettuce, much more manure may doubtless be used with profit than would be profitable where manure has been used abundantly with previous crops.

Where the use of manure is continued year after year on soil originally not rich enough to force good lettuce the optimum amount may be expected to decline first towards 10 per ct., eventually to approach 5 per ct.

The amount of manure which may be used with good economy in forcing lettuce varies with the character of the soil and of the manure, and also with the differences in prices received for fancy lettuce and ordinary lettuce. For these reasons no definite amount can be recommended.

Repeated applications of excessive quantities of manure to the same soil are not good economy. Manure is thus wasted and the yield may be reduced.

Where large amounts of manure were incorporated in the soil for forcing lettuce the yield was increased by compacting the soil. This shows that unfavorable effects which follow excessive applications of manure may be caused in part, at least, by thereby loosening the soil so much as to put it in an unfavorable mechanical condition for the lettuce plant.

The clay loam used in these experiments has always proved superior to the light sandy loam for forcing lettuce when both were fertilized with equal amounts of stable manure.

INTRODUCTION.

In forcing lettuce may nitrogenous commercial fertilizers be used profitably either with or without the addition of stable manure? This is a question of considerable importance to those

who are engaged in growing lettuce under glass. In preparing the soil for forcing lettuce it is not unusual for market gardeners to cover it from 2 to 3 inches deep with manure and then work the manure in. Some growers recommend applications 1 or 2 inches deep.[1] If another lettuce crop is to follow the first one immediately, another, though perhaps less heavy, application of manure is made as soon as the first crop is removed. In some lettuce houses, and especially in those of modern type, the soil is not often renewed and the repeated heavy applications of manure supply it with humus and plant-food in great abundance. May there not be an extravagant use of manure under such circumstances?

One of the authors reports in Bulletin 146 of this Station some investigations bearing on this point. It is there shown that the amount of manure which may be profitably used in forcing lettuce varies with different soils; also that the use of excessive quantities of manure has a detrimental effect on the crop as compared with more moderate use. It appears, therefore, that many gardeners in trying to make the soil very rich for forcing lettuce overdo the matter and not only waste that portion of the manure which exceeds the requirements of the crop *but reduce the yield below that which would be given on the same kind of soil with less manure.*

On subsequent pages there is given an account of our investigations bearing upon the economical use of manure in forcing lettuce and also upon the question of profitably combining nitrogenous commercial fertilizers with stable manure or substituting them for it in forcing this crop. Before passing to the consideration of this work it will be well to inquire what has been previously published on the subject.

PREVIOUS INVESTIGATIONS.

Scarcely any mention of fertilizer experiments on lettuce under glass is found in European literature. The investigations on this subject which have thus far been reported have been

[1]*Amer. Gard.*, Supplement of Jan. 22, 1898; *Rural N. Y.*, 1898:871.

almost wholly confined to American agricultural experiment stations. The most important results of these investigations are summarized in the following paragraphs. Mr. F. H. Hall has kindly assisted in preparing this summary.

In experiments in 1888–9 by Maynard,[2] on lettuce under glass, muriate and sulphate of potash, nitrate of soda, sulphate of ammonia and dissolved bone black were used on two crops; the same fertilizers and nitrate of potash on a third crop. These were applied dissolved in water, but the amounts used and the character of the soil are not stated. Mildew affected all plats, the nitrate of soda plat worst.

Sulphate of ammonia gave the best lettuce with two crops, but a decidedly inferior product for the third crop. Nitrate of soda, and both muriate and sulphate of potash were of no benefit; even apparently injurious in some crops, the results with sulphate being quite unfavorable. Bone black gave conflicting results. The single test with nitrate of potash showed apparent benefit.

In 1892 Green[3] applied various nitrogenous fertilizers to lettuce and other greenhouse crops on a rich compost, using double the amount applied in outdoor work. No benefit was obtained, thus showing that the limitations of these fertilizers, so far as stimulating plant growth on such soil is concerned, are narrower than some had supposed.

In 1892–3 Goessmann[4] grew lettuce under glass on a sandy loam very low in humus and fertilizing ingredients. Commercial fertilizers and chemicals were used in various combinations, each box receiving the same amount of nitrogen, potash and phosphoric acid, the last always in dissolved bone black.

Maynard's results with muriate of potash were confirmed by the strikingly unfavorable influence shown by it in these tests; but, contrary to his experience, potash in the simple sulphate or the magnesia sulphate gave the most satisfactory growth.

---

[2] Maynard, S. T. Mass. Hatch Sta. Bul. 10:1–5 (1890).

[3] Green, W. J. Ohio Sta. Bul. 43:100, 101.

[4] Goessmann, C. A. Mass. State Sta. Ann. Rept. 1893:241–261.

In the following year, where a combination of phosphate of ammonia and sulphate of potash was used, supplying the soil .0004 per ct. of potash and .0001 per ct. each of phosphoric acid and nitrogen, the seed did not germinate well nor the plants grow vigorously.

Sulphate of ammonia in combination gave poorer results in every case than the other forms of nitrogen. As in previous tests, the results with muriate of potash were less favorable than those with the sulphate. Carbonate of potash-magnesia with dissolved bone black and dried blood or with double superphosphate and nitrate of soda gave very satisfactory growth. Goessmann concludes that soluble saline compounds should not be used in excess in lettuce fertilizers, especially not under glass.

Jenkins and Britton[5] report interesting data on the amount of nitrogen taken from the soil by forced lettuce and the quantity necessary to supply in fertilizers to meet this demand. The soil used was sifted anthracite coal ashes mixed with 5 per ct. of peat moss and fertilized with sufficient quantities of chemicals. Simpson White-seeded Tennis Ball lettuce was, after two transplantings, grown to maturity on this medium.

The lettuce was of good quality, though not claimed to be equal to the best grown in rich natural soil. The time of growth is not stated. The draft on the soil by the entire plants of 1000 heads of lettuce thus grown was 282.6 grams nitrogen, 87.7 grams phosphoric acid and 621 grams potash. To meet this demand would require fertilizers equivalent to 1105 lbs. per acre of nitrate of soda, 331 lbs. dissolved bone black and 394 lbs. muriate of potash.

In 1897 Watts[6] published a report of some experiments in which nitrate of soda gave good results when applied three times to loose lettuce in pots. It was applied to each pot at the rate of $\frac{3}{8}$ oz. dissolved in one-half pint of water, making the total amount for the season $1\frac{1}{8}$ ozs. per plant.

---

[5] Jenkins and Britton. Conn. State Sta. Ann. Rept. 1895:93–95.

[6] Watts, R. L. Tenn. Agr. Exp. Sta. Bul., X, 2:27.

Jenkins and Britton[7] continued the experiments previously noted and found that, on the coal-ash and peat-moss soil, 1.8 grams nitrogen, .56 gram phosphoric acid and 3.03 grams potash per square foot gave as good results as larger amounts. This is equivalent to 1079 lbs. nitrate of soda, 320.4 lbs. dissolved bone black and 582.8 lbs. muriate of potash per acre. The mixture of coal ashes with 5 per ct. of peat moss gave larger yields than coal ashes alone, but was not equal to mixtures containing 9 to 12 per ct. of moss. None of these mixtures gave as much or as good lettuce as compost soil (sod and manure rotted) with the same amounts of fertilizers. Head lettuce and loose lettuce gave the best results on rich compost soils without either lime or chemical fertilizers. The results on the limed plats were better than on the chemical fertilizer plats.

In 1900 these authors[8] report much better crops from compost without chemical fertilizers than from the coal-ash and peat-moss mixtures with such fertilizers. On this artificial soil nitrogen in ground bone gave best results; in cotton-seed meal, poorer results, and in nitrate of soda poorest results. The authors believe that the poor texture of both the coal-ash and peat-moss mixture and the compost make it impossible to produce on them lettuce of the best quality. The character of the compost is not given.

Stuart,[9] in the winter of 1896–7, used chemical fertilizers in growing lettuce on a black loam soil unfertilized for several years and believed to be quite deficient in plant-food. Different plats were supplied liberally with muriate of potash alone or in combination with either or both dissolved bone black and nitrate of soda. A loose lettuce, Grand Rapids, was grown on all plats. The watering was by sub-irrigation. The muriate alone or with nitrate of soda gave unfavorable results, as in tests of Maynard and Goessmann; but the muriate with dissolved bone black gave a marked increase in the crop. The

---

[7] Jenkins and Britton. Conn. State Exp. Sta. Rept. 1899:224–226.

[8] Conn. State Sta. Rept. 1900:298–301.

[9] Stuart, Wm. Ind. Sta. Bul. 66 (Oct., 1897).

results were similar, though less marked, for the muriate in combinations, when a second crop was grown on the same plats without additional fertilizer; but the injurious effect of the muriate alone had worn off, apparently, for the yield with it was greater than on the check plats.

Nitrate of soda with both muriate of potash and dissolved bone black appeared beneficial, instead of injurious as when combined with muriate alone.

In this connection the results of Brooks and Thomson's[10] field experiments with onions are of interest. They found that liming the soil or the free use of dissolved bone black overcame the unfavorable effects from the continued use of muriate of potash alone or the more unfavorable results when it is used with nitrate of soda. The presence of sulphate of lime in the dissolved bone black probably accounts for the corrective influence of the latter.

Experiments at this Station[11] from 1895 to 1898 devoted principally to the merits of different soil mixtures for forcing lettuce, were also planned to show the effects of some different fertilizers. On a soil containing 15.5 per ct. by weight (25 per ct. by bulk) of manure, nitrate of soda gave a slight increase in growth, but when the soil contained 33 1-3 per ct. of manure, the use of the nitrate made no better growth.

Acid phosphate, 600 lbs. per acre, and sulphate of potash, 400 lbs., did not increase the crop on the 15.5 per ct. manure soil; but doubling these amounts of phosphoric acid and potash gave later maturing and slightly heavier heads of lettuce than the manure alone. The addition of 33 1-3 per ct. of manure to sandy loam soil resulted in poorer crops of lettuce than were grown on the same soil with commercial fertilizers. On clay loam the manure gave excellent crops better than the fertilizers without manure. The cumulative effect of fertilizers was not studied, the soils being renewed each year.

---

[10] Brooks, W. P., and Thomson, H. M. Mass. Hatch Sta. Ann. Rept. 1891:108–112.

[11] Beach S. A. N. Y. Agrl. Exp. Sta. Bul. 146:151–179; also Ann Rept. 1898:461–491.

In Jordan's[12] experiments in New Jersey, extending from 1896 to 1899, seven crops were grown on a prepared soil (3 parts turfy loam, 2 parts manure and 1 part sand), on clay soil and on sandy loam. The fertilizer plats all received muriate of potash, 200 lbs. per acre, and acid phosphate, 350 lbs., with 320 lbs. nitrate of soda or equivalent nitrogen in sulphate of ammonia or dried blood. The prepared soil alone gave one-fifth better results than the same soil with fertilizers, and was not equalled by the other soils, fertilized or unfertilized. The use of lime on the prepared soil decreased the yield 12 per ct., but increased the yield where chemicals were used.

Card[13], in 1899, grew lettuce in pots, with results indicating that chemicals would give as good lettuce as stable manure. In 1900 he grew three crops on the greenhouse bench and, in coöperative work, two crops on a solid bed in a commercial forcing house. Chemical ferilizers were far behind stable manure in yields produced, even on soil lightened by adding moss and sand. In the commercial house, presumably on a rich loam soil, with a layer of manure under the soil a top dressing of bone black, nitrate of soda, muriate and sulphate of potash gave better lettuce than a top dressing of manure. In a second test this combination with ground bone in place of bone black gave better results than acid phosphate, nitrate of soda and sulphate of potash combined or any two of them together.

In continuing his experiments, Stuart[14] used much smaller proportions of muriate of potash than in former tests. Little difference was observed between the muriate and sulphate when they were used with raw bone meal alone or with the bone meal and nitrate of soda; and the difference favored the muriate.

The stable manure tests are especially interesting in connection with the experiments to which this bulletin is devoted. Black loam soil deficient in plant-food, fertilized with acid phos-

---

[12] Jordan, A. T. N. J. Agrl. Exp. Sta. Rept. 1899:149–159.

[13] Card, F. W. R. I. Sta. Repts., 1899:135, and 1900:252.

[14] Stuart, Wm. Ind. Sta. Bul. 84 : 115–142 (1900). See also *Amer. Gard.* 21:94.

phate alone or in combination with either nitrate of soda or muriate of potash or both, all in liberal quantities, did not give as good a crop as a soil made of sod composted with one-fourth its bulk of stable manure; but where a very heavy application of raw bone meal was made the yield was 7 per ct. greater than with the compost. The acid phosphate, muriate of potash and nitrate of soda combination gave a yield nearly equal to that on the compost, but with the other applications the yield was much reduced.

In the next experiment the black loam soil was mixed with an equal bulk of stable manure, and gave a considerably better crop than was secured from the use of raw bone meal alone or combined with either nitrate of soda or muriate of potash, but a poorer yield than that from the three fertilizers combined.

Nine different fertilizers or fertilizer combinations were tested in the next experiment. Manure made up half the bulk of one soil, five-eighths that of another. In the first crop both manured soils gave poorer yields than any other fertilizer or combination; in the second crop, on the unchanged soils, the pots containing one-half manure ranked seventh in yield, those containing five-eighths manure, first. The comparatively slight differences in the higher yields of the previously mentioned experiments might be attributed to differences in the kind of plant-food or to variations in vigor of the plants. Some other explanation must be given for the great deficiency in yield on the manure pots in the first crop in this test, especially since one of the manured soils without more plant-food gave the largest yield in the second crop. The extremely low yields with manure in the first crop parallel some of our results showing deleterious effect when excessive quantities of manure were used, with superior results from less manure.

For immediate results nitrate of soda did better than dried blood, but where a second crop was grown without repeating the application of the fertilizers the dried blood gave the better results.

OUR INVESTIGATIONS FROM 1898 TO 1901.

GENERAL CONDITIONS.

OBJECT OF TESTS.

We have called attention on pages 323 and 327 to the methods of using stable manure which are often practiced by gardeners in forcing lettuce and to the investigations bearing upon this subject which were published in Bulletin 146 of this Station. The experiments which are now reported form a portion of the series of investigations begun in 1895 concerning the selection and preparation of soils for forcing lettuce and the economical use of stable manure and commercial fertilizers for this crop. In the fall of 1898 the experiments were directed to the question of the use of nitrogenous fertilizers. It was decided to try commercial nitrogenous fertilizers for forcing lettuce both with and without stable manure. Director Jordan assisted in formulating the plans for testing these fertilizers. His counsel has also been sought at various times during the progress of the work. In the fall of 1900 Mr. Hasselbring became associated in the work. He has assisted in taking notes and in preparing this account of the experiments for publication.

THE HOUSE.

The experiments were conducted in the forcing house which had been used for the preceding investigations. Its arrange-

ment is illustrated and partly described in Bulletin 146.[15] It is of iron-frame construction and is so arranged that the conditions of light, heat and ventilation may be kept remarkably uniform throughout. The portion used for the plants is separated from the walls by walks. The plants were grown in boxes arranged on benches as indicated in the diagram opposite. The numbers in this diagram correspond to the soil treatment numbers given in Table IV.

THE BOXES.

In testing the action of particular factors upon plants it is essential that all conditions be under the best possible control so that the other factors which are not being tested shall be uniform. At the same time it is desirable that the conditions of the experiment conform to ordinary horticultural practice so far as this can be done without lessening the reliability of the test. It was decided that these conditions could best be fulfilled in these experiments by growing the plants in small wooden boxes. These have an advantage over benches or sections of benches in that plants receiving similar treatment may be distributed in various locations in the house. With such an arrangement there is a tendency to equalize in the average results any inequalities which may exist in the environment in different locations in the house. Moreover boxes may be easily handled for weighing or photographing. The boxes were made 15 x 15 x 8 inches inside. They were not filled quite to the top and some space at the bottom was occupied with gravel for drainage so that the soil in each box was about 7 inches deep, which is not far from the depth of soil ordinarily found on greenhouse benches. The boxes easily accommodate four lettuce plants, one near each corner.

THE SOILS.

Both a medium clay loam and a very light sandy loam were used in these experiments. Each particular treatment as regards

[15] N. Y. Agr. Exp. Sta. Bul. 146 : 162 and Pl. II; Ann. Rept. 1898 : 471 and Pl. XLIV.

fertilizers was tried upon both kinds of soil.[16] The clay loam was composed of rotted sod from an uncultivated field. The sandy loam was from the side of a cultivated field where part of it had been drifted by winds. It could not support nearly so heavy a sod as the clay loam, and contained less humus and also less nitrogen, phosphoric acid and potash, as the following analyses show. These analyses were made by Messrs. W. H. Andrews and A. D. Cook.

TABLE I.—ANALYSES OF THE CLAY LOAM AND THE SANDY LOAM.

(AIR DRIED SAMPLES.)

Soil.	Nitrogen. (N.)	Phosphoric acid. (P_2O_5.)	Potash. (K_2O.)
	Per ct.	*Per ct.*	*Per ct.*
Clay loam	0.215	0.075	0.469
Sandy loam	0.052	0.067	0.121

NITROGENOUS FERTILIZERS TESTED.

In these tests organic nitrogen was used in the forms of stable manure and dried blood, and inorganic nitrogen in the forms of nitrate of soda and sulphate of ammonia. These are among the most important nitrogenous fertilizers of commerce. The chemical fertilizers just mentioned were tried both with and without

[16] These soils were similar to those used in the work of 1897–8, air-dried samples of which, as determined by official methods, gave the following analyses. (See Bul. 146 and Ann Rept. 1898.)

TABLE A.—CHEMICAL ANALYSES OF CLAY LOAM AND SANDY LOAM.

(CROP OF 1897-8.)

Soil.	Moisture. (H_2O.)	Nitrogen. (N.)	Phosphoric acid. (P_2O_5.)	Potash (K_2O.)	Lime. (CaO.)	Organic matter.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Clay loam	13.3	.237	.067	.318	1.022	7.81
Clay loam, water-free.......	0.	.236	.077	.368	1.179	9.01
Sandy loam	14.0	.075	.111	.083	.343	2.68
Sandy loam, water-free......	0.	.087	.129	.097	.399	3.12

TABLE B.—MECHANICAL ANALYSES OF CLAY LOAM AND SANDY LOAM.

(CROP OF 1897-8.)

	Clay Loam.	Sandy loam.
	Per ct.	*Per ct*
Fine gravel....................................	3.32	0.51
Coarse sand....................................	5.20	0.69
Medium sand....................................	20.71	9.49
Fine sand......................................	43.45	77.50
Very fine sand.................................	.94	2.44
Silt	7.96	1.60
Fine silt......................................	1.64	1.23
Clay	9.86*	3.79†
Organic matter.................................	7.02	2.75

*Including 4.39 unsettled clay. †Including 1.03 unsettled clay.

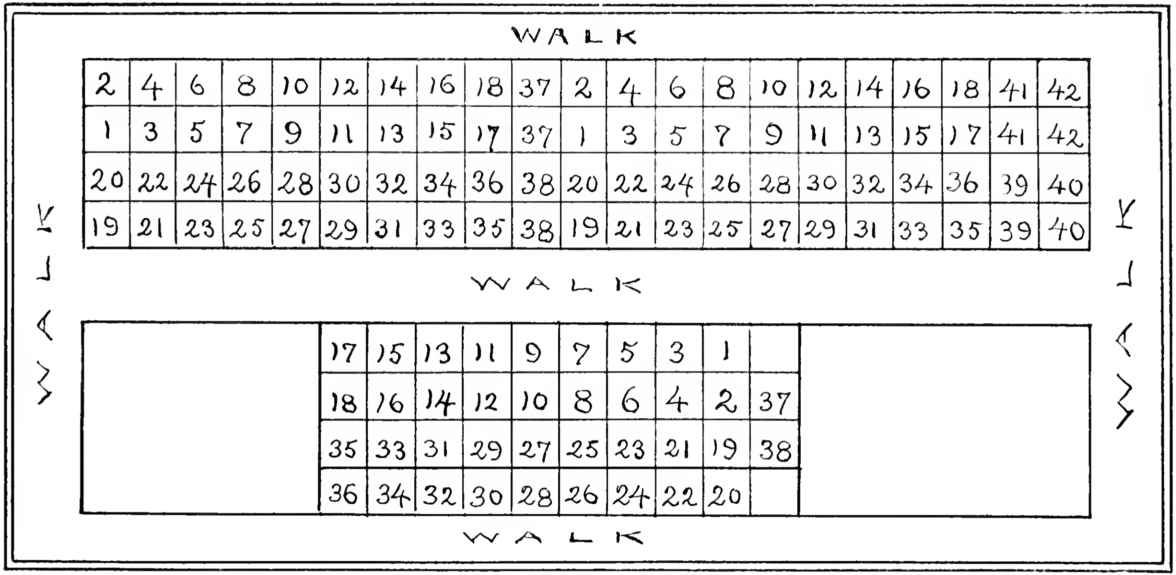
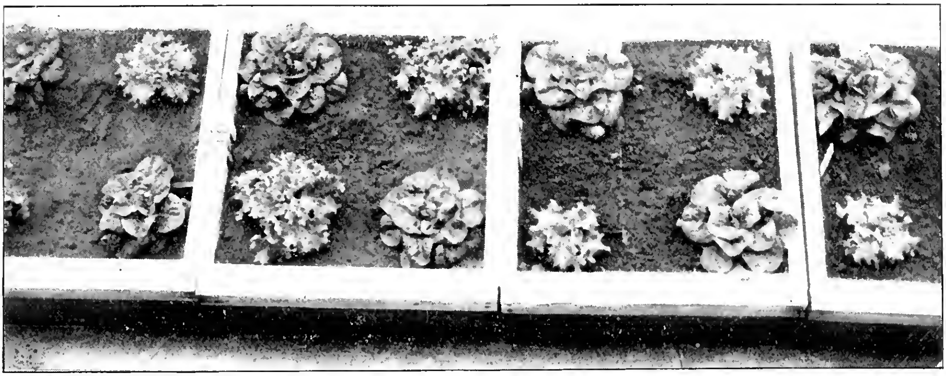
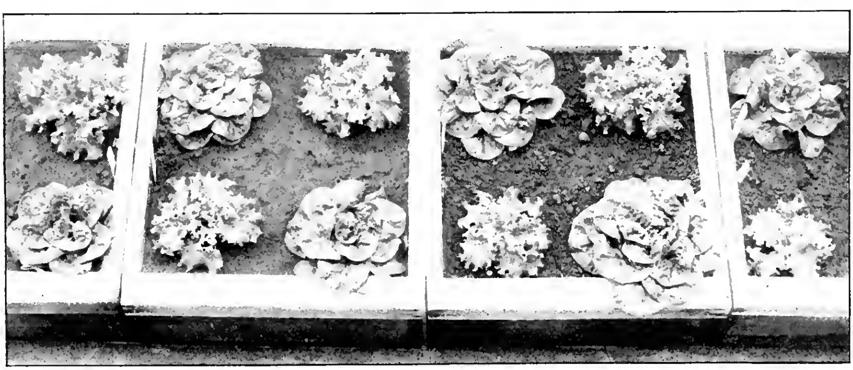


PLATE XXV.—DIAGRAM SHOWING ARRANGEMENT OF BOXES FOR THE DIFFERENT SOIL TREATMENTS. SEE TABLE IV.



SANDY LOAM. CLAY LOAM.

FIG. 1. NEITHER COMMERCIAL FERTILIZERS NOR STABLE MANURE.



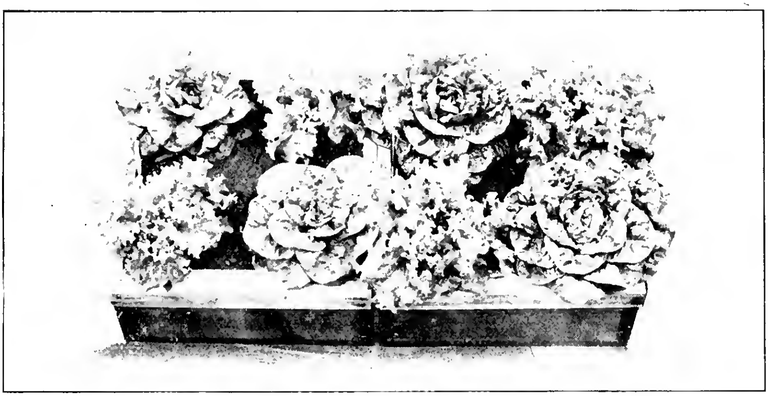
SANDY LOAM. CLAY LOAM.

FIG. 2. COMMERCIAL FERTILIZERS BUT NO MANURE.

PLATE XXVI.—CROP OF 1900-'01.
(Photographed a few days before harvesting.)

SANDY LOAM. CLAY LOAM.

FIG. 1. COMMERCIAL FERTILIZERS AND 5 PER CT. MANURE.



SANDY LOAM. CLAY LOAM.

FIG. 2. COMMERCIAL FERTILIZERS AND 10 PER CT. MANURE.

SANDY LOAM. CLAY LOAM.

FIG. 3. COMMERCIAL FERTILIZERS AND 20 PER CT. MANURE.

PLATE XXVII.—CROP OF 1900-'01.

(Photographed a few days before harvesting.)

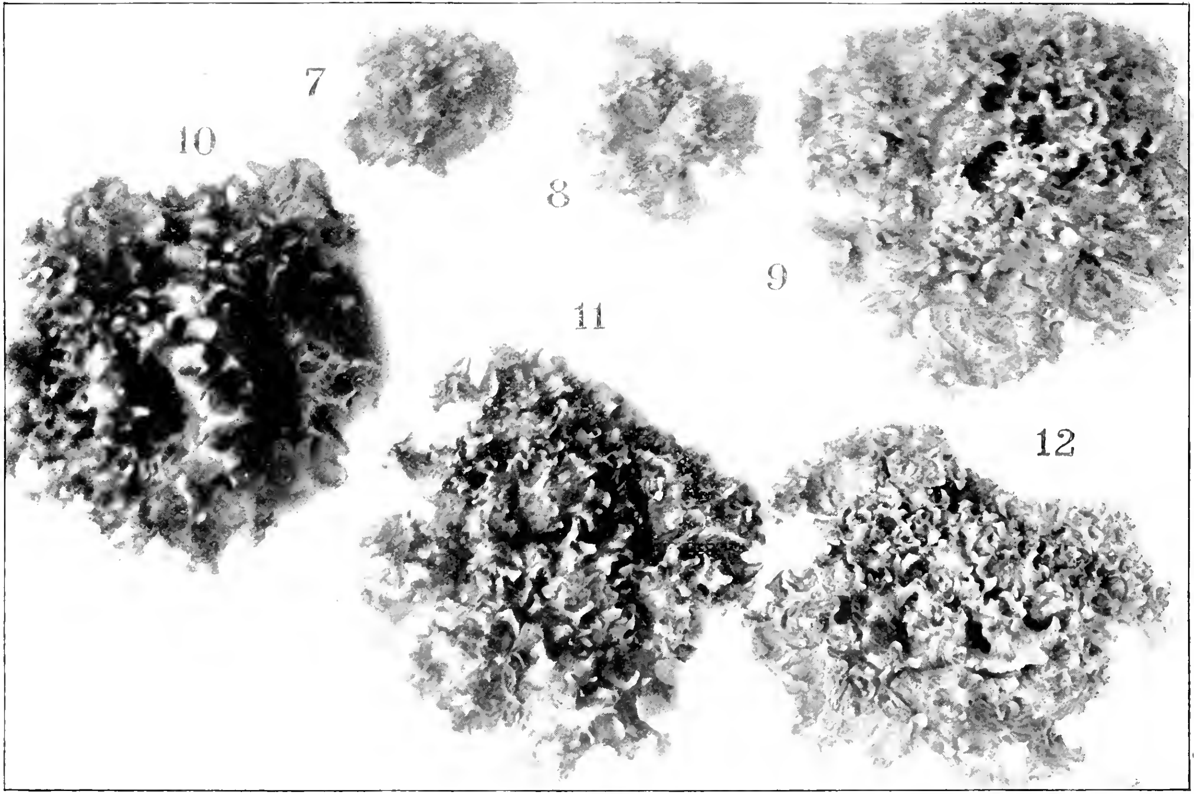


Plate XXVIII.—Crop of 1900-'01, Grand Rapids Lettuce on Sandy Loam.
No. 7, no fertilizer, no manure; No. 8, complete commercial fertilizer, no manure; Nos. 9, 10, 11, 12, complete commercial fertilizer and 5, 10, 15 and 20 per ct. manure, respectively.

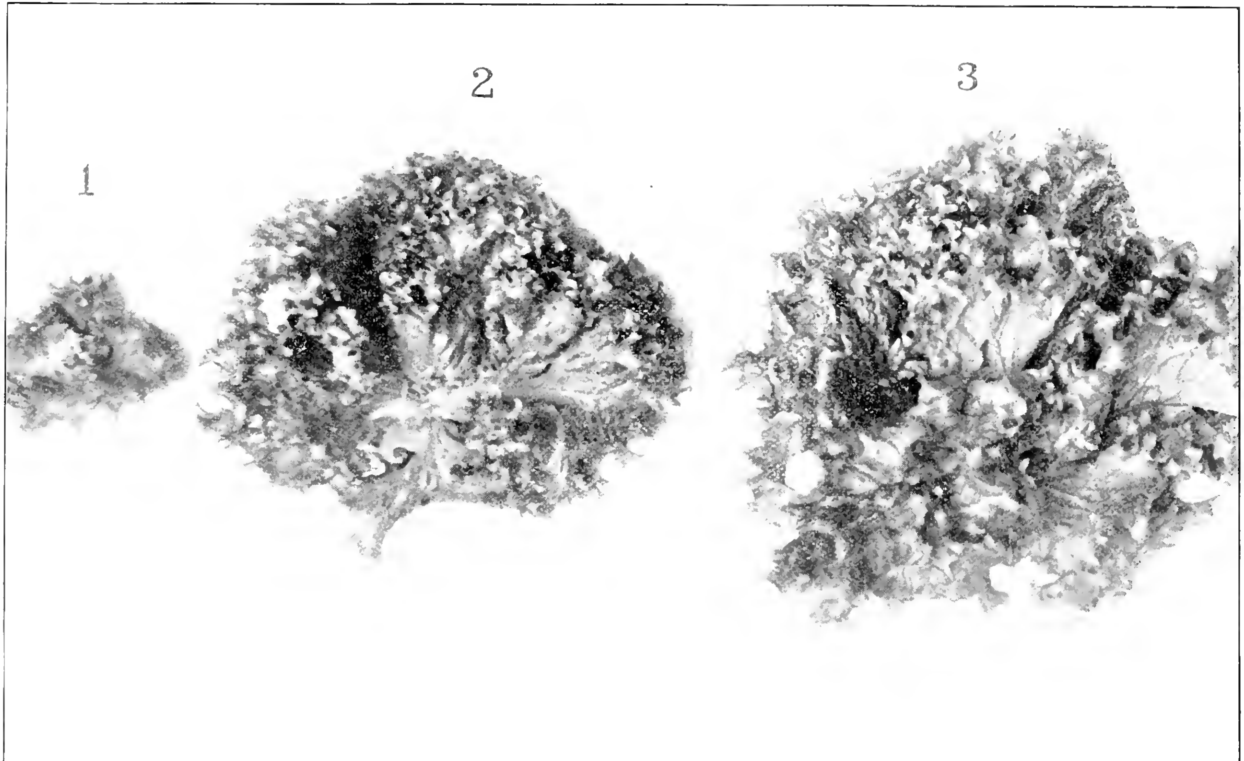


PLATE XXIX.—CROP OF 1900-'01, GRAND RAPIDS LETTUCE ON CLAY LOAM.
No. 1, no fertilizer, no manure; No. 2, complete commercial fertilizer, no manure; No. 3, fertilizer and 5 per ct. manure.

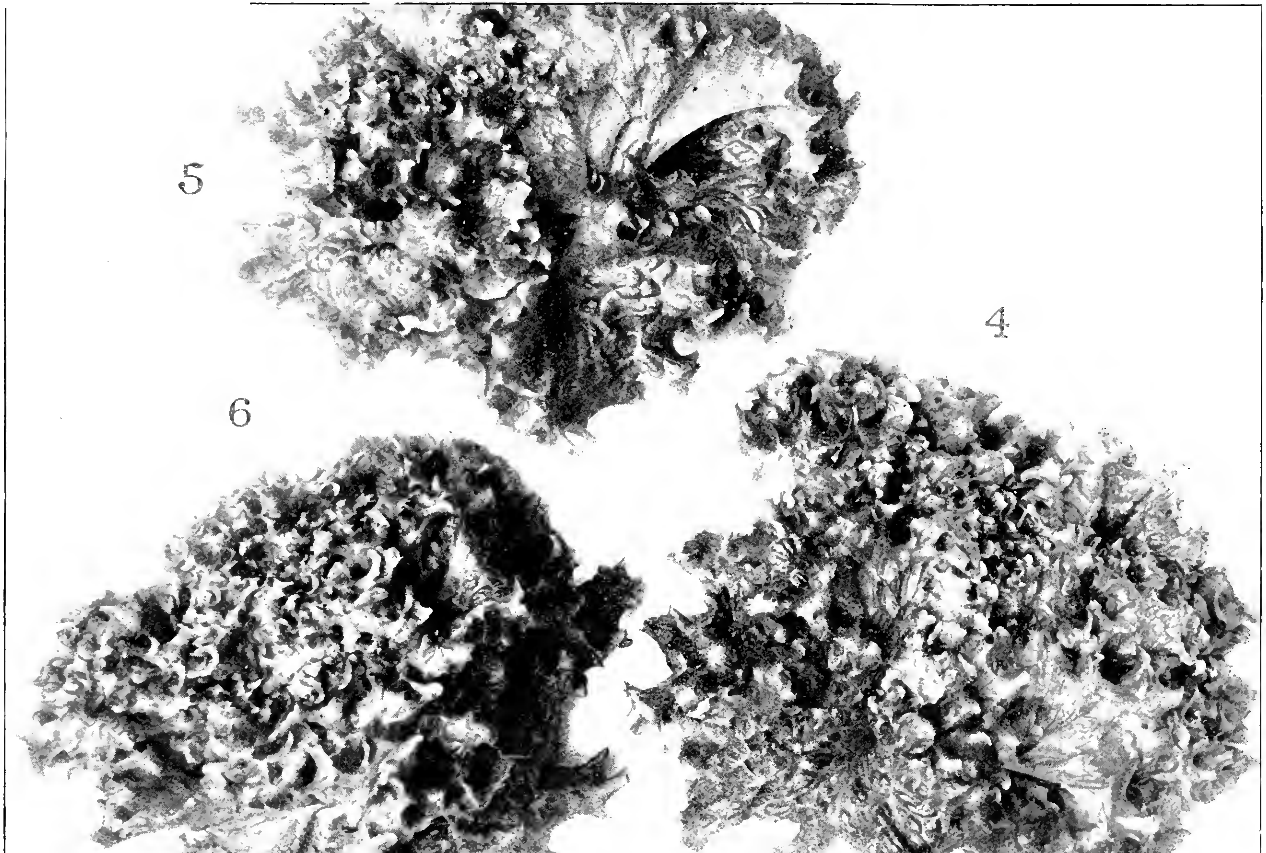


PLATE XXX.—CROP OF 1900-'01, GRAND RAPIDS LETTUCE ON CLAY LOAM.
Nos. 4, 5, 6, complete commercial fertilizer and 10, 15 and 20 per ct. manure, respectively.

Fig. 1. Neither Commercial Fertilizers nor Stable Manure.

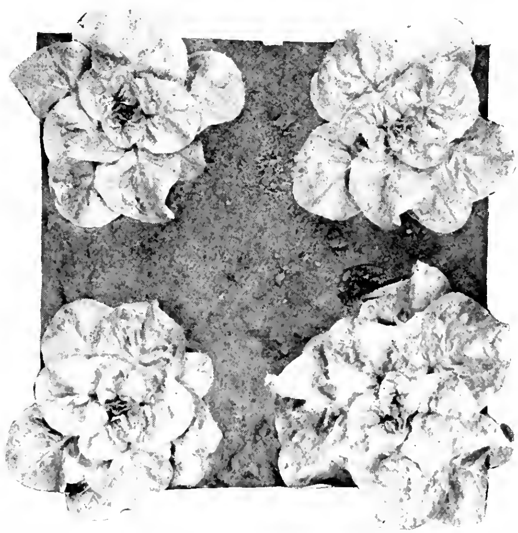


Fig. 2. Commercial Fertilizers but no Stable Manure.

Plate XXXI.—Crop of 1898-'9, on Sandy Loam.

(Photographed about three weeks before harvesting.)

Fig. 1. Commercial Fertilizers and 5 per Ct. Manure.

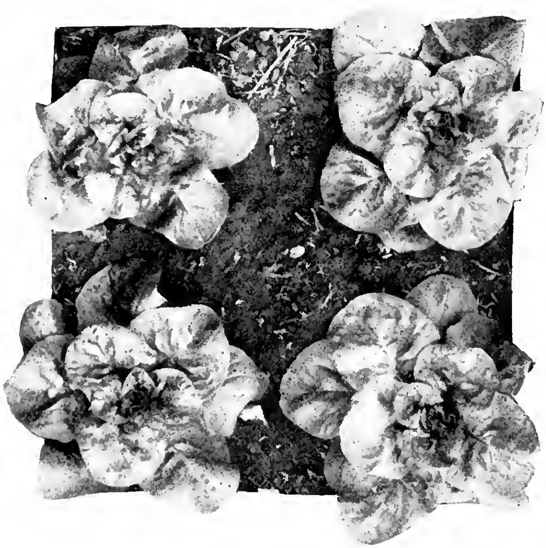


Fig. 2. Commercial Fertilizers and 10 Per Ct. Manure.

Plate XXXII.—Crop of 1898-'9, on Sandy Loam.
(Photographed about three weeks before harvesting.)

Fig. 1. On Sandy Loam.

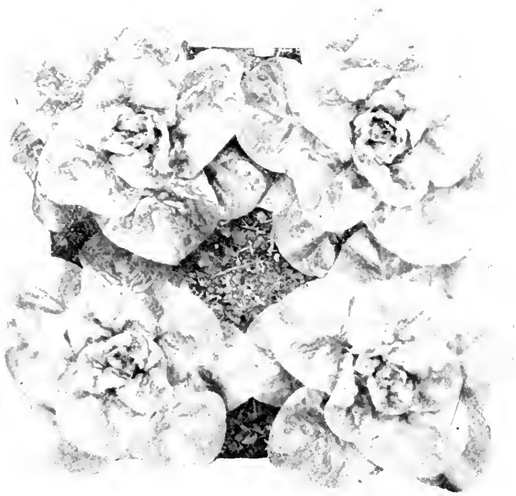


Fig. 2. On Clay Loam.

Plate XXXIII.—Crop of 1898-'9. Commercial Fertilizers with 20 Per Ct. Manure.

(Photographed about three weeks before harvesting.)

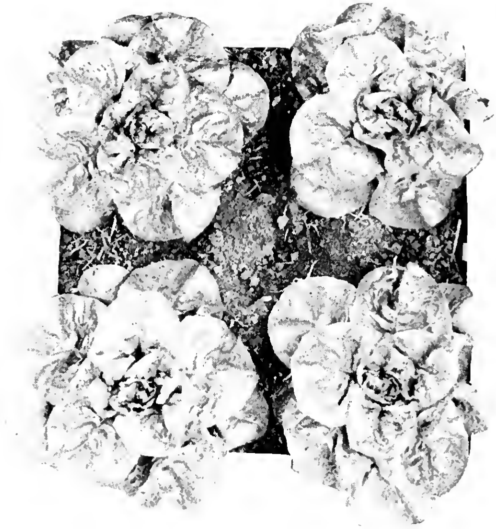


FIG. 1. COMMERCIAL FERTILIZERS AND 10 PER CT. MANURE.

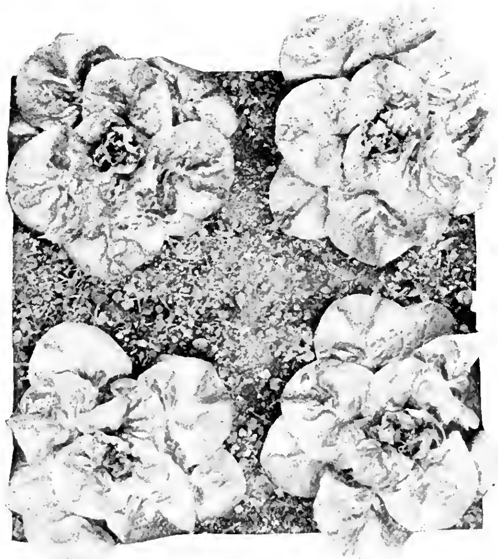


FIG. 2. COMMERCIAL FERTILIZERS AND 5 PER CT. MANURE.

PLATE XXXIV.—CROP OF 1898-'9, ON CLAY LOAM.
(Photographed about three weeks before harvesting.)

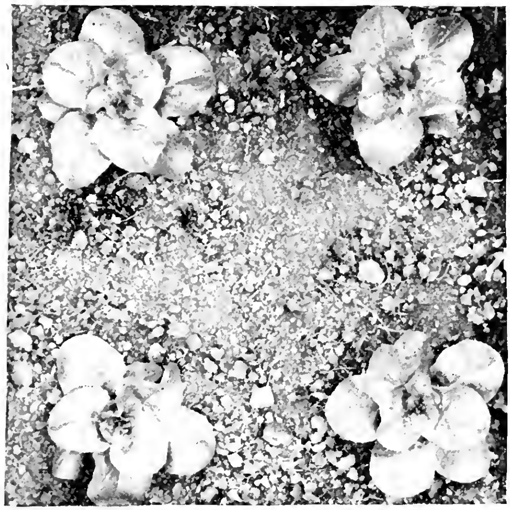


Fig. 1. Commercial Fertilizers but no Manure.

Fig. 2. Neither Commercial Fertilizers Nor Stable Manure.

Plate XXXV.—Crop of 1898-'9, on Clay Loam.
(Photographed about three weeks before harvesting.)

stable manure, the latter being used in different amounts on different portions of soil. Although stable manure is very rich in nitrogen it contains other kinds of plant-food including important amounts of phosphoric acid and potash. Besides this it adds humus to the soil and changes its physical condition in such a way as to modify the soil fertility. For these reasons it cannot be classed as a simple nitrogenous fertilizer, and therefore is not comparable as such with the other nitrogenous fertilizers above mentioned.

In previous tests where manure constituted 33 1-3 per ct. by weight of the soil no increased growth followed the application of nitrate of soda but where it constituted but 15.5 per ct. of the weight the addition of nitrate of soda was followed by some increase in the crop. In view of these facts it was decided to try the nitrogenous chemical fertilizers on soils containing 15 per ct. by weight of stable manure and compare the results with those obtained with similar applications to similar portions of soil having greater amounts of manure and to others having less. For the first crop, therefore, manure in combination with chemical fertilizers was used on different portions of soil at the rate of 5 per ct., 10 per ct., 15 per ct. and 20 per ct. by weight, and on still other portions without chemical fertilizers at the rate of 33 1-3 per ct. by bulk. In the last mentioned instance part of the soil was compacted very firmly and the rest left loose without being shaken or packed at all, the object being to note to what extent the growth might be influenced by the difference in mechanical condition of the same soil mixture which was thus produced.

For comparison with these, other portions of soil were given similar applications of the chemical fertilizers only, while still others received nothing. To each portion except the last and those which received one-third manure by bulk, phosphoric acid and potash were added in liberal quantities.

The applications, whether of manure or of chemical fertilizers, were repeated in each instance for each succeeding crop of lettuce in the same amounts as at first except that after the first

crop the manure was applied at the rate of 5 per ct., 10 per ct., 15 per ct. and 20 per ct. by bulk, instead of by weight. In order that the cumulative effects of the treatments might be seen the soil was in no case renewed from 1898 till 1901.

PREPARATION OF SOIL.

The clay loam was thoroughly mixed before being separated into the various portions to be used in the experiments. In this way its composition was rendered as uniform throughout as possible. The sandy loam was similarly treated. Whenever a portion of soil was to receive an application of manure this was made for the first crop before it was measured into the boxes, but for the following crops it was made to each box separately. Three boxes were filled from each portion except those portions which were mixed with one-third manure by bulk. From each of the latter four boxes were filled, the soil in two being packed firmly and in the other two left loose as already explained. Where commercial fertilizers were used they were applied to each box of soil separately as hereafter described.

FERTILIZERS.

The manure.—The manure was well rotted horse manure. For the first crop it was applied to different portions of soil at the rate of 5 per ct., 10 per ct., 15 per ct. and 20 per ct. by weight, and 33⅓ per ct. by bulk, but for the succeeding crops it was used at the rate of 5 per ct., 10 per ct., 15 per ct., 20 per ct. and 33⅓ per ct. by bulk, as has already been stated. This also appears in the table on p. 337.

The average weight per cubic foot of clay loam when prepared for the first crop was about 68 pounds, and for the sandy loam about 70 pounds. The area of each box was 225 square inches; the contents of the part occupied by the soil was 1575 cubic inches. From these data the following table is derived. It shows for both the clay loam and the sandy loam, the different percentages of manure by weight with the corresponding percentages by bulk, the rate per acre in cords and in tons, and the depth to which the manure would cover the soil when spread evenly over the entire surface.

TABLE II.—PROPORTIONS TO SOIL AND AMOUNTS PER ACRE OF MANURE USED.

CROP OF 1898–99.

Kind of soil.	Proportion by weight.	Proportion by bulk.	Rate per acre.		Depth on soil.
	Per ct.	*Per ct.*	*Cords.*	*Tons.*	*Ins.*
Clay loam..............	5	11⅓	22+	43+	0.79⅓
	10	22⅔	44+	86+	1.58⅔
	15	34	67+	129+	2.38
	20	45⅓	89+	172+	3.17⅔
	14.7+	33⅓	66+	126+	2.33⅓
Sandy loam............	5	11.72+	23+	44+	0.82+
	10	23.44+	46+	88+	1.64+
	15	35.16+	96+	133+	2.46+
	20	46.88+	92+	177+	3.28+
	14.2+	33⅓	66+	126+	2.33⅓

CROPS OF 1899–1900 AND 1900–1901.

Kind of soil	Proportion by bulk.	Depth on soil.	Amount per acre. 1899–1900.		1900–01.
	Per ct.	*Ins.*	*Cords.*	*Tons.*	*Tons.*
Clay loam and sandy loam..	5	.35	9.90	16.8+	17.58+
	10	.70	19.80	33.6+	35.17+
	15	1.05	29.70	50.4+	52.76+
	20	1.40	39.60	67.2+	70.35+
	33⅓	2.33⅓	66.00	111.0+	117.26+

Enough manure to supply all the demands of the different portions of soil was passed through a sieve of 1-inch x 1½-inch mesh, the rough parts were discarded, and it was all thoroughly mixed before any portion of the soil was manured. This was done to secure as uniform composition as possible. The required portion of soil was then weighed out or measured by volume according to the requirements of each particular case, the manure was added and both were thoroughly mixed together before any commercial fertilizers were added.

Application of commercial fertilizers.—The required amounts of the commercial fertilizers were weighed out for each box of soil. The exact amount of soil required for the box was spread upon a clean cement floor A part of the commercial fertilizers were scattered upon it; the pile was then well mixed and more of the fertilizers added. This process was repeated till the application of the fertilizers was complete. After still further mixing, the soil was put into the box designed for it.

Excepting those which were left untreated for checks, the boxes were each given potash, phosphoric acid and nitrogen in the form of commercial fertilizers. The potash was always added in the form of the sulphate at the rate of 400 lbs. per acre; the phosphoric acid in the form of acid phosphate at the rate of 600 lbs. per acre; the nitrogen in dried blood and nitrate of soda either combined or separately, or in sulphate of ammonia. The different combinations of commercial fertilizers in which nitrogen was applied are shown in the following statement:

TABLE III.—COMBINATIONS OF COMMERCIAL FERTILIZERS IN WHICH NITROGEN WAS APPLIED.

	Amount per acre				
Series.	Sulphate of potash.	Acid phosphate	Dried blood.	Nitrate of soda.	Sulphate of ammonia.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Dried blood..............	400	600	1000	0	0
Nitrate of soda...........	400	600	0	600	0
Dried blood and nitrate of soda	400	600	850	100	0
Sulphate of ammonia.....	400	600	0	0	480

The actual potash thus applied was in each case 204+ lbs. per acre; of actual phosphoric acid 98+ lbs.; of nitrogen in the dried blood series 99+ lbs.; in the nitrate of soda series 91+ lbs.; in the dried blood and nitrate of soda series 99+ lbs. and in the sulphate of ammonia series 100+ lbs. It is clear that the supply of potash and phosphoric acid was in each case the same and of nitrogen approximately the same, being a little less in the nitrate of soda series than in the others. Any marked variations in the results with the different series may therefore signify a difference in the action of the nitrogenous fertilizers which are to be compared.

Commercial fertilizers and stable manure combined or used separately.—Each series of the nitrogenous fertilizers mentioned above was used alone and also in combination with different amounts of stable manure, both on the clay loam and on the sandy loam. In some of the check boxes stable manure was also tried without any commercial fertilizers on sandy loam and

on clay loam at the rate of one-third of the bulk of the soil; and in others, as has already been stated, neither commercial fertilizers nor stable manure was used. All of this is shown in the following statement:

TABLE IV.—SHOWING THE TREATMENTS OF THE VARIOUS PORTIONS OF SOIL.

Soil treatment number.		Stable manure.		Commercial fertilizers. Rate per acre for each crop.				
Clay loam.	Sandy loam.	1898'-99. Proportion by weight.	1899-'00 and 1990-'01. Proportion by bulk.	Sulphate of potash.	Acid phosphate.	Dried blood.	Nitrate of soda.	Sulphate of ammonia.
		Per ct.	*Per ct.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	19	0	0	400	600	1000	0	0
2	20	0	0	400	600	0	600	0
3	21	0	0	400	600	850	100	0
4	22	0	0	400	600	0	0	480
5	23	5	5	400	600	1000	0	0
6	24	5	5	400	600	0	600	0
7	25	5	5	400	600	850	100	0
8	26	10	10	400	600	1000	0	0
9	27	10	10	400	600	0	600	0
10	28	10	10	400	600	850	100	0
11	29	10	10	400	600	0	0	480
12	30	15	15	400	600	1000	0	0
13	31	15	15	400	600	0	600	0
14	32	15	15	400	600	850	100	0
15	33	20	20	400	600	1000	0	0
16	34	20	20	400	600	0	600	0
17	35	20	20	400	600	850	100	0
18	36	20	20	400	600	0	0	480
37	38	0	0	0	0	0	0	0
41	39	*	33⅓	0	0	0	0	0
42	40	*	33⅓	0	0	0	0	0

* To the portions of soil which were numbered 39, 40, 41 and 42 the manure was always applied at the rate of 33⅓ per ct. by bulk In 1898-99 this was equivalent to 14 7 per ct. by weight on the clay loam and 14.2 per ct. on the sandy loam. See Table II.

SELECTING AND PLANTING THE SEED.

The seed was selected and planted with the utmost care to secure plants as uniform as possible in natural vigor and habit of growth. To this end selection was also made of the little plants soon after the first leaves expanded. Four plants were

grown in each box, one near each corner. Holes for the seeds were made one-half inch deep by means of a marker designed for this express purpose. About a dozen large plump seeds were planted in each hole, and covered evenly with fine earth. After germination all but the most vigorous plants were discarded. By this method good plants were selected. These were not transplanted but grew where the seeds were planted, undisturbed till they were harvested. Although transplanting is not necessarily injurious to lettuce nevertheless there is always a risk that some of the plants may not pass through the operation as successfully as others. Where the plants are under experiment, therefore, transplanting should be avoided; because it is liable to introduce disturbing factors.

In case a plant under experiment was accidently injured or died prematurely its place was immediately filled with another plant of the same kind and age, grown for the purpose of meeting such an emergency, so that the number of plants in each box might be kept uniform during the entire period of growth and the portion of soil available to each plant under experiment might be kept as uniform as possible.

WATERING.

Hydrant water from the city supply was applied to the surface whenever the plants needed it. No attempt was made to measure the quantity used. The small percentage of plant-food supplied in the water may be disregarded in such experiments as those under consideration. After the heads began to form, the water was applied around the plants and wetting the heads was avoided as much as possible. Where water is applied to the heads the leaves are apt to hold more of it than readily evaporates and thus conditions favorable to the development of rot are obtained.

Up to the time when the leaves covered the soil, cultivation followed watering as soon as the ground was fit. This kept down weeds and conserved soil moisture.

The watering was usually done early enough in the day to have the atmosphere dry at night. On bright days the atmosphere was made moist by wetting the walks and floors, and the plants were syringed lightly if they showed a tendency to wilt.

VENTILATION AND TEMPERATURE.

The ventilation was managed so as to avoid cold draughts and sudden changes in temperature. The greatest care was required to prevent tipburn after the plants began to head. On a bright day following a period of dull dark weather the temperature was constantly watched and especial care taken to hold it nearly as low as it had been on the dark days and at the same time the atmosphere was kept moist by following the method above described.

The night temperature was kept between 45° and 55°; the day temperature from 60° to 65° in dull weather, but on sunny days it was allowed to run up to 70°. During the period of germination and also just before the plants matured the temperature was kept somewhat lower than it was during the season of more active growth.

HARVESTING THE CROP.

The crop was not cut till the earliest-maturing heads had fully developed into prime marketable condition. Then the whole crop was cut. The loose lettuce and head lettuce were not cut at the same time, however, because the crops did not mature at the same time. In 1899-00 the head lettuce was cut about two weeks before it would have matured, as explained in the notes for that crop.

Each head was weighed as soon as it was cut, before it had a chance to lose weight by evaporation. Full records were made of the character of the plant, including its weight. The limits of this report will not permit the publication of all these data, but so much of them is given as appears necessary to establish the facts brought out by the investigation.

NOTES ON CROPS.

SEASON OF 1898-99.

Rawson Hothouse, a variety of head lettuce, was used alone for the crop of 1898-99. The seed was sown Dec. 30, 1898. Germination began to show Jan. 6. The plants were thinned after the manner already described till but one was left in each place. Within a month after planting it was evident that on the check soils the lettuce was suffering from lack of food. The plants were stunted and the foliage bronzed. In the clay loam without manure the use of commercial fertilizers resulted in a somewhat better growth, but the plants were not always as good in color, nor were they in nearly so vigorous, growing condition as the plants on soils treated with manure. The differences between these plants and those on corresponding soils which received manure was very marked. On the latter soils the plants, although yet small, were healthy and growing rapidly. These differences became more pronounced as the plants developed.

The entire crop was harvested Apr. 3. Each plant was cut at the surface of the ground and immediately weighed. The average weight per plant for each of the different treatments and the ratio of the yield to the yield on the corresponding check soil are shown in the table on page 345. It was apparent that the use of the commercial fertilizers did not force the crop as rapidly to maturity as did the stable manure, although it resulted in a decided gain in yield as compared with the check soils. The addition of even the least amount of manure which was used, 5 per ct. by weight, showed a striking increase in the crop. Thus, while the 12 heads of lettuce from the soil which received dried blood but no manure averaged 0.75 oz. per head, the 12 heads on corresponding soil to which 5 per ct. of manure was added weighed, on the average, 4.13 ozs. per head. This increase is all the more significant, because the former had received in commercial fertilizers far more plant food than a full crop contains. It indicates that the proper use of

stable manure gives distinct advantages for forcing crops aside from the available plant-food which is thereby added to the soil. In this crop the yield, as a rule, increased with each increase of manure, although not to a corresponding degree. With succeeding crops the yield, where the larger amounts of manure were used, oftentimes was less than that obtained with smaller amounts, as we shall see later. The soils which received manure only, at the rate of one-third their bulk, and which were packed firmly into the boxes, gave a better yield than any other portions; better even than those which received as much or more manure combined with commercial fertilizers. Less increase was seen with the corresponding loose soil, but even in this case the yield on the sandy loam exceeded that where more manure was used in combination with commercial fertilizers, and on the clay loam it exceeded that obtained with an approximately equal amount of manure combined with the commercial fertilizers.

The relative value of the different forms of the nitrogenous commercial fertilizers shown on the soils where no manure was used did not hold good when these fertilizers were combined with the stable manure. The addition of even 5 per ct. by weight ($11\frac{1}{3}$ per ct. by bulk) of the manure obscured the individual action of the nitrogenous commercial fertilizers. Those who wish to follow the results in this line more fully are referred to the data set forth in Tables V to IX.

Where manure was used the crop on the sandy loam was very much below that obtained with similar treatment on the clay loam. The soils which received no manure show an interesting exception to this with this crop but not with succeeding crops. See Tables V to IX.

SEASON OF 1899–1900.

The experiments in 1899–1900 were conducted on the same general plan as those of the preceding year. The few changes mentioned below were introduced. The same soil was used. It was prepared by dumping the box, adding to the soil the stable manure or commercial fertilizer, if any was required, and after

thoroughly mixing returning it to the same box. The quantities of manure were reduced from 5 per ct., 10 per ct., 15 per ct., or 20 per ct. by weight, to 5 per ct., 10 per ct., 15 per ct., or 20 per ct. by bulk, respectively. See Table II. This made the actual amount considerably smaller than that given to the same box for the previous year. So far as influencing the experiment is concerned, it need only be said that the relative amounts added to the different series remain the same. Moreover, the composition of the manure varied in the different seasons. The total amount added to any particular box may be easily calculated. In experiments of this kind the exact amount of plant-food available to each plant or set of plants cannot be accurately determined. All that is expected is to know the kind, relative amounts and composition of the plant-food which is added to the various portions of soil under experiment.

A further change consisted in the use of a loose lettuce, the Grand Rapids, in addition to the Rawson Hothouse head lettuce, two plants of each variety being grown in each box.

The seed was planted Oct. 7, in the same manner as before. Germination began to appear Oct. 13. The loose lettuce was all cut Jan. 15 and 16. The crop could not be held longer without having the most advanced plants begin to deteriorate.

The head lettuce was harvested Jan. 30. It was not then mature; but for lack of strict attention to ventilation and watering during a period of sunshine following dull weather, tipburn had made its appearance. The crop was at once harvested for fear that rot might follow the tipburn and vitiate the results of the work.

Some of the facts established both by observation of the growing plants and by the weights of the different yields are given in the following statements:

As to the effect of commercial fertilizers when used without manure, the nitrate of soda gave best results on the clay loam. Sulphate of ammonia gave much the best results with loose lettuce on the sandy loam and was unsurpassed with the head lettuce. It should be noticed, however, that this was an excep-

tionally good record for the sulphate of ammonia when used without manure and it was not in accord with its record either with the preceding or the following crop except where it was used in combination with lime.

Both kinds of lettuce did better on the clay loam than on the sandy loam. This is very noticeable with the check crops. The check crop on the clay loam exceeded that on the sandy loam in the ratio of 7 to 1.

SEASON OF 1900–01.

The experiments in 1900–01 followed the lines of the preceding year's work except that one box of the three included in each soil treatment was given one ounce of air-slaked lime when the soil was mixed. Occasional tests of the soil made previously had failed to discover any acidity, but it was desirable to learn whether or not the repeated application of the commercial fertilizers had brought about unfavorable conditions which the lime would correct. The use of the lime was, almost without exception, followed by more or less unfavorable results. In some cases the yield was but slightly decreased, in most cases it was noticeably decreased and in a few cases the yield was not even half that obtained on the unlimed soils. Where nitrate of soda was applied without manure to sandy loam and where sulphate of ammonia was used without manure on the clay loam, the limed soils gave somewhat better yields than those not limed.

The seed was planted in the usual manner Sept. 28. The head lettuce came through all right but for some reason not understood the loose lettuce did not. It was replanted Oct. 9. This time it grew all right, but of course it remained more backward than the head lettuce. The head lettuce grew rapidly on the soils which received manure, being markedly superior from the start to that on the soils which were not manured. On the whole the highest yield of head lettuce came from the use of 10 per ct. manure, but that from 5 per ct. was nearly as large. With 33⅓ per ct. manure and no commercial fertilizers the yield in each case fell below the average of the boxes having 5 per ct. manure combined with commercial fertilizers, as also, usually, did the

yield from boxes having 20 per ct. manure combined with commercial fertilizers. These remarks hold good also for the loose lettuce though not in the same degree. The loose lettuce seemed to be less affected by the excessive use of manure and to the eye the entire crop appeared more uniform and less influenced by the differences in the treatment of the soil than did the head lettuce. The head lettuce was harvested Jan. 14, when the earliest maturing heads were ready to be cut. The loose lettuce was cut Jan. 31.

RESULTS AS SHOWN BY THE WEIGHTS OF THE THREE LETTUCE CROPS.

The average weight per plant, both of the head lettuce and of the loose lettuce, is shown below for each crop and each separate treatment. The number of plants from which the average yield is deduced is stated and also the ratio of that average to the average of corresponding untreated, or check, plants, the latter being always considered as a unit. It should be remembered that the value of the unit or check for the clay loam differs from that of the sandy loam with each crop; it also differs on the same kind of loam with the different crops.

Table V.—Results with Crop of Head Lettuce, 1898–99.

Series.	Manure: By bulk.	Manure: By weight.	Nitrogenous com. fert.	Clay loam, A.: No. of plants.	Clay loam, A.: Average weight per plant.	Clay loam, A.: Check = 1. treated.	Sandy loam, F.: No. of plants.	Sandy loam, F.: Average weight per plant.	Sandy loam, F.: Check = 1, treated =
	Per ct.	*Per ct*	*Lbs.*[1]		*Ozs.*	=		*Ozs.*	
Dried blood	0	0	1000	12	.750	2.25	12	2.104	3.00
Nitrate of soda...	0	0	600	12	.938	2.82	12	2.313	3.30
Nitrate of soda and dried blood.	0	0	100 850	12	.771	2.31	12	1.729	2.47
Sulphate ammonia	0	0	480	12	1.104	3.31	12	.917	1.31
Dried blood	11⅓	5	1000	11	4.136	12.44	12	2.792	3.99
Nitrate of soda...	11⅓	5	600	12	4.438	13.31	11	2.659	3.79
Nitrate of soda and dried blood	11⅓	5	100 850	12	4.250	12.75	12	2.542	3.63
Dried blood	22⅔	10	1000	12	5.104	15.31	12	3.000	4.30
Nitrate of soda...	22⅔	10	600	12	4.438	13.31	11	3.205	4.57
Nitrate of soda and dried blood.	22⅔	10	100 850	10	5.125	15.38	12	3.104	4.43
Sulphate ammonia	22⅔	10	480	12	4.396	13.19	12	2.792	3.99
Dried blood	34	15	1000	12	5.229	15.69	12	2.979	4.26
Nitrate of soda...	34	15	600	11	4.795	14.39	11	2.932	4.19
Nitrate of soda and dried blood.	34	15	100 850	12	5.188	15.56	12	2.833	4.05
Dried blood	45⅓	20	1000	12	5.646	16.94	12	2.708	3.87
Nitrate of soda...	45⅓	20	600	12	6.063	18.19	12	3.292	4.70
Nitrate of soda and dried blood.	45⅓	20	100 850	12	5.875	17.63	12	3.063	4.37
Sulphate ammonia	45⅓	20	480	12	5.938	17.81	12	3.354	4.79
No commercial fertilizer	33⅓	14.7	0[2]	8	6.219	18.66	8	4.281	6.11
No commercial fertilizer	33⅓	14.7	0[3]	8	5.594	16.78	7	3.607	5.15
Nothing	0	0	0	12	.33⅓	1.00	12	.698	1.00

[1] Per acre; with 400 lbs. sulphate of potash and 600 lbs. acid phosphate. [2] Soil packed firmly in box. [3] Soil loose.

TABLE VI.—RESULTS WITH CROP OF HEAD LETTUCE, 1899–1900.

Series.	Manu'e by bulk.	Nitrogenous com. fert.	Clay loam, B. No. of plants.	Clay loam, B. Average weight per plant.	Clay loam, B. Check = 1, treated =	Sandy loam, G. No. of plants.	Sandy loam, G. Average weight per plant.	Sandy loam, G. Check = 1, treated =
	Per ct.	*Lbs.*		*Ozs.*			*Ozs.*	
Dried blood........	0	1000	6	1.583	2.02	6	.175	2.33
Nitrate of soda.....	0	600	6	2.203	2.82	6	.150	2.00
Nitrate of soda and dried blood.......	0	100 / 850	6	1.667	2.13	6	.033	.45
Sulphate ammonia..	0	480	6	1.677	2.13	6	.175	2.33
Dried blood........	5	1000	6	5.000	6.38	6	2.000	26.67
Nitrate of soda.....	5	600	6	4.708	6.01	6	1.958	26.11
Nitrate of soda and dried blood.......	5	100 / 850	6	5.042	6.44	6	1.417	18.89
Dried blood........	10	1000	6	5.125	6.54	6	2.875	38.33
Nitrate of soda.....	10	600	6	4.750	6.06	6	2.542	33.89
Nitrate of soda and dried blood.......	10	100 / 850	6	5.042	6.44	6	2.917	38.89
Sulphate ammonia..	10	480	6	4.708	6.01	6	2.292	30.56
Dried blood........	15	1000	6	5.250	6.70	6	2.750	36.67
Nitrate of soda.....	15	600	6	5.208	6.65	5	2.850	38.00
Nitrate of soda and dried blood.......	15	100 / 850	6	4.917	6.28	5	3.150	42.00
Dried blood........	20	1000	6	4.375	5.59	5	3.100	41.33
Nitrate of soda.....	20	600	6	4.375	5.59	6	3.167	42.22
Nitrate of soda and dried blood......	20	100 / 850	6	4.792	6.12	6	2.625	35.00
Sulphate ammonia..	20	480	6	4.917	6.28	6	2.792	37.22
No commercial fertilizer	33⅓	0[2]	4	5.063	6.46	2	2.875	38.33
No commercial fertilizer	33⅓	0[3]	4	3.500	4.47	4	1.875	25.00
Nothing	0	0	6	.783	1.00	6	.075	1.00

[1] Per acre; with 400 lbs. sulphate of potash and 600 lbs. acid phosphate. [2] Soil packed firmly in box. [3] Soil loose.

TABLE VII.—RESULTS WITH CROP OF LOOSE LETTUCE, 1899-1900.

Series.	Manu'e by bulk.	Nitrogenous com. fert.	Clay loam, C.			Sandy loam, H.		
			No. of plants.	Average weight per plant.	Check =1, treated =	No. of plants.	Average weight per plant.	Check =1, treated =
	Per ct.	Lbs.[1]		Ozs.			Ozs.	
Dried blood........	0	1000	6	1.187	1.50	6	.333	2.94
Nitrate of soda.....	0	600	6	1.875	2.37	6	.250	2.21
Nitrate of soda and dried blood.......	0	{ 100 / 850	6	1.608	2.03	6	.1[illegible]2	1.08
Sulphate ammonia..	0	480	6	1.600	2.02	6	.492	4.34
Dried blood........	5	1000	5	3.750	4.74	6	1.458	12.87
Nitrate of soda.....	5	600	6	3.542	4.47	5	1.550	13.68
Nitrate of soda and dried blood.......	5	{ 100 / 850	6	3.708	4.68	6	1.375	12.13
Dried blood........	10	1000	6	3.792	4.79	6	1.833	16.18
Nitrate of soda.....	10	600	6	3.792	4.79	6	1.667	14.71
Nitrate of soda and dried blood.......	10	{ 100 / 850	6	4.000	5.05	6	1.708	15.07
Sulphate ammonia..	10	480	6	4.208	5.31	6	1.583	13.97
Dried blood........	15	1000	6	3.958	5.00	6	1.708	15.07
Nitrate of soda.....	15	600	6	3.583	4.53	6	1.625	14.34
Nitrate of soda and dried blood.......	15	{ 100 / 850	6	3.833	4.84	6	2.125	18.75
Dried blood........	20	1000	5	3.900	4.93	6	1.750	15.44
Nitrate of soda.....	20	600	5	3.350	4.23	6	1.583	13.97
Nitrate of soda and dried blood.......	20	{ 100 / 850	6	2.750	3.47	6	1.333	11.76
Sulphate ammonia..	20	480	6	3.458	4.37	6	1.583	13.97
No commercial fertilizer	33⅓	0[2]	4	3.813	4.82	4	2.063	18.20
No commercial fertilizer	33⅓	0[3]	4	2.313	2.92	4	1.063	9.38
Nothing	0	0	6	.792	1.00	6	.113	1.00

[1] Per acre; with 400 lbs. sulphate of potash and 600 lbs. acid phosphate. [2] Soil packed firmly in box. [3] Soil loose.

TABLE VIII.—RESULTS WITH CROP OF HEAD LETTUCE, 1900–1901.

Series.	Manu'e by bulk.	Nitrogenous com. fert.	Clay loam, D. No. of plants.	Clay loam, D. Average weight per plant.	Clay loam, D. Check =1, treated =	Sandy loam, I. No. of plants.	Sandy loam, I. Average weight per plant.	Sandy loam, I. Check =1, treated =
	Per ct.	*Lbs.*[1]		*Ozs.*			*Ozs.*	
Dried blood	0	1000	6	1.583	1.65	6	1.208	1.53
Nitrate of soda	0	600	6	1.625	1.69	6	.792	1.00
Nitrate of soda and dried blood	0	800 100	6	1.750	1.82	6	1.250	1.58
Sulphate ammonia	0	480	6	1.417	1.46	6	1.042	1.32
Dried blood	5	1000	6	4.417	4.60	5	2.400	3.03
Nitrate of soda	5	600	6	3.875	4.04	6	1.958	2.48
Nitrate of soda and dried blood	5	100 800	6	4.875	5.08	5	2.800	3.55
Dried blood	10	1000	6	4.792	5.00	6	3.708	4.69
Nitrate of soda	10	600	6	4.042	4.21	6	2.708	3.43
Nitrate of soda and dried blood	10	100 800	6	4.583	4.78	5	2.750	3.48
Sulphate ammonia	10	480	6	4.875	5.08	6	2.917	3.69
Dried blood	15	1000	6	4.708	4.91	4	2.125	2.68
Nitrate of soda	15	600	6	4.250	4.43	5	3.050	3.85
Nitrate of soda and dried blood	15	100 800	6	3.625	3.78	6	1.625	2.05
Dried blood	20	1000	4	4.000	4.16	5	2.250	2.85
Nitrate of soda	20	600	5	3.750	3.91	5	1.450	1.83
Nitrate of soda and dried blood	20	100 800	6	3.333	3.47	4	1.813	2.29
Sulphate ammonia	20	480	6	4.250	4.43	5	2.750	3.48
No commercial fertilizer	33⅓	0[2]	4	4.688	4.89	4	1.813	2.29
No commercial fertilizer	33⅓	0[3]	4	4.062	4.24	3	1.667	2.11
Nothing	0	0	6	.958	1.00	6	.792	1.00

[1] Per acre; with 400 lbs. sulphate of potash and 600 lbs. acid phosphate. [2] Soil packed firmly in box. [3] Soil loose.

Table IX.—Results with Crop of Loose Lettuce, 1900-1901.

			Clay loam, E.			Sandy loam, J.		
Series.	Manu're by bulk.	Nitrogenous com. fert.	No. of plants.	Average weight per plant.	Check =1, treated =	No. of plants.	Average weight per plant.	Check =1 treated =
	Per ct.	Lbs.[1]		Ozs.			Ozs.	
Dried blood........	0	1000	6	.875	1.75	5	1.150	1.38
Nitrate of soda.....	0	600	6	.833	1.66	6	.917	1.10
Nitrate of soda and dried blood.......	0	100 850	6	.916	1.83	6	1.458	1.75
Sulphate ammonia..	0	480	6	.833	1.66	6	1.000	1.20
Dried blood........	5	1000	6	3.792	7.58	6	2.542	3.05
Nitrate of soda.....	5	600	6	3.000	6.00	6	2.042	2.45
Nitrate of soda and dried blood.......	5	100 850	6	3.708	7.42	5	2.100	2.52
Dried blood........	10	1000	6	3.833	7.66	5	3.050	3.65
Nitrate of soda.....	10	600	6	3.166	6.33	4	2.625	3.15
Nitrate of soda and dried blood.......	10	100 850	6	3.750	7.50	6	2.583	3.10
Sulphate ammonia..	10	480	6	4.083	8.16	6	2.625	3.15
Dried blood........	15	1000	5	3.650	7.30	6	3.208	3.85
Nitrate of soda.....	15	600	6	3.417	6.83	6	2.292	2.75
Nitrate of soda and dried blood.......	15	100 850	6	3.208	6.42	6	2.583	3.10
Dried blood........	20	1000	6	3.250	6.50	5	2.500	3.06
Nitrate of soda.....	20	600	6	2.958	5.92	6	2.583	3.10
Nitrate of soda and dried blood.......	20	100 850	6	3.542	7.08	6	1.917	2.30
Sulphate ammonia..	20	480	6	2.792	5.58	6	2.917	3.50
No commercial fertilizer	33⅓	0[2]	4	3.875	7.75	4	1.875	2.25
No commercial fertilizer	33⅓	0[3]	4	2.938	5.88	4	1.500	1.801
Nothing	0	0	6	.500	1.00	6	.833	1.00

[1] Per acre; with 400 lbs. sulphate of potash and 600 lbs. acid phosphate. [2] Soil packed firmly in box. [3] Soil loose.

GENERAL DISCUSSION OF THE RESULTS.

What is the testimony of these experiments on the question as to whether nitrogenous commercial fertilizers may be used with profit in forcing lettuce either with or without stable manure? The data which have already been presented will now be considered with reference to their bearing upon this question.

RESULTS FROM USING THE COMMERCIAL FERTILIZERS WITHOUT MANURE.

Both on the sandy loam and on the clay loam, where no manure was used the addition of the commercial fertilizers resulted in a decided increase in yield over the untreated soil. On the clay loam the nitrate of soda generally appeared to be more beneficial than either the dried blood or the dried blood combined with the nitrate of soda, and with one exception did equally as well or better than sulphate of ammonia. On the sandy loam it was not so beneficial as dried blood except with the first crop, when it proved somewhat better; but it proved superior to sulphate of ammonia except with the second crop. The use of lime with the nitrate of soda gave an improved crop on the sandy loam but decreased the crop on the clay loam.

The results with sulphate of ammonia without manure were very variable with the different crops. On clay loam it was superior to both nitrate of soda and dried blood in the first crop and inferior to both in the last. On the sandy soil the results were also variable; in one instance it gave the highest yield with the crop of loose lettuce, and it was generally more or less superior to the nitrate of soda but inferior to dried blood.

The dried blood when used without manure generally gave better results on the sandy soil but not so good results on the clay soil as the commercial fertilizers did with which it was compared.

RESULTS FROM COMBINING THE COMMERCIAL FERTILIZERS WITH MANURE.

When manure was applied in addition to the commercial fertilizers very much better crops were obtained than when the latter only were used. This is clearly shown in the following

table where the yield when commercial fertilizers only were applied is compared with the yield on similar portions of soil to which stable manure was added at the lowest rate tested in this work, 5 per ct.

TABLE X.—SUMMARY OF RESULTS WITH COMMERCIAL FERTILIZERS WITHOUT MANURE AND WITH FIVE PER CT. OF MANURE.

Treatment.	Check[1]=1, treated plants= On clay loam. With head lettuce. From To	On clay loam. With loose lettuce. From To	On sandy loam. With head lettuce. From To	On sandy loam. With loose lettuce. From To
CROP OF 1898–1899:				
Commercial fertilizers without manure	2.25–3.31		1.31–3.30	
Commercial fertilizers with 5 per ct. manure[2]	12.44–13.31		3.63–3.99	
CROP OF 1899–1900:				
Commercial fertilizers without manure	2.02–2.82	1.50–2.37	0.45–2.33	1.08–4.34
Commercial fertilizers with 5 per ct. manure[2]	6.01–6.44	4.47–4.74	18.89–26.67	12.45–13.27
CROP OF 1900–1901:				
Commercial fertilizers without manure	1.46–1.82	1.66–1.83	1.00–1.58	1.10–1.75
Commercial fertilizers with 5 per ct. manure[2]	4.04–5.08	6.00–7.58	2.48–3.55	2.45–2.52

[1] The value of the check varies with the different crops and with the different soils. See Tables V to IX.

[2] The manure was added to these portions of soil at the rate of 5 per ct. by weight for the first crop and 5 per ct. by bulk for succeeding crops. See Table II.

In every trial of these commercial fertilizers alone they proved entirely inadequate for bringing a crop to maturity in sufficiently short time to be profitable. This held true not only for the earlier crops but also for the last crop where the cumulative effect of the applications for the two previous years had the best chance to appear. Had the tests been made with garden loam enriched in previous years by liberal applications of manure or with sod and manure compost such as gardeners usually prepare for forcing lettuce, perhaps the results would have been much more favorable to commercial fertilizers alone, but for the kind of soils which were used in these experiments the evidence is con-

clusive that lettuce can be forced much more successfully by using manure than by using commercial fertilizers alone.

With the higher percentages of manure the influence of the nitrogenous commercial fertilizers is much obscured as the variable results with the 15 per ct. and 20 per ct. applications show, but with the 5 per ct. and 10 per ct. applications results were obtained which may give some indication of the comparative value of these fertilizers when combined with the smaller percentages of manure. An examination of Tables V to IX with reference to the variation in yield which followed the use of the various nitrogenous commercial fertilizers in combination with 5 per ct. and 10 per ct. of manure shows that a better crop was obtained with dried blood than with nitrate of soda in 16 tests, while the reverse was found in but 3 tests, and in one test there was no difference in yield. The yield with dried blood was better than that with sulphate of ammonia in 7 tests while the reverse was found in but three tests. The yield with dried blood was better than with dried blood combined with nitrate of soda in 11 tests while the reverse was true in 9 cases. In many instances the differences in yield are too slight to be of themselves significant but taken in the aggregate they do seem to indicate that the dried blood combined with moderate quantities of stable manure is more effective in stimulating the growth of lettuce than either nitrate of soda or sulphate of ammonia similarly combined. Also they indicate that the dried blood does as well for this purpose when combined with manure as does the combination of nitrate of soda, dried blood and manure.

HOW MUCH MANURE SHOULD BE USED?

The question then arises: How much manure may be used with profit in forcing lettuce? According to our experience and observation gardeners ordinarily use from 5 per ct. to 20 per ct. by bulk and more often approach the 20 per ct. than the 5 per ct. rate. The results where manure was used in combination with dried blood will first be examined. They are arranged in the following table such a way that the yield under each treatment may be compared with the yield of the corresponding check.

Table XI.—Comparative Yields in Dried Blood Series Without Manure and With Different Proportions of Manure.

CLAY LOAM.

Crop.	No manure or com. fert.	Comparative yields with— [2] Manure, by weight. None.	5 p. ct.[1]	10 p. ct.[1]	15 p. ct.[1]	20 p. ct.[1]		
Head lettuce, 1898–1899..	12	2.25	12.44	15.31	15.69	16.94		
		[2] Manure, by bulk.					33⅓ p. ct.[3]	
		None.	5 p. ct.	10 p. ct.	15 p. ct.	20 p. ct.	Packed.	Loose.
Head lettuce,								
1898–1899..	1						18.66	16.78
1899–1900..	1	2.02	6.38	6.54	6.70	5.59	6.46	4.47
1900–1901..	1	1.65	4.60	5.00	4.91	4.16	4.89	4.24
Loose lettuce,								
1899–1900..	1	1.50	4.74	4.79	5.00	4.93	4.82	2.92
1900–1901..	1	1.75	7.58	7.66	7.30	6.50	7.75	5.88

SANDY LOAM.

Crop.	No manure or com. fert.	[2] Manure, by weight. None.	5 p. ct.[1]	10 p. ct.[1]	15 p. ct.	20 p. ct.[1]		
Head lettuce, 1898–1899..	1	3.00	3.99	4.30	4.26	3.87		
		[2] Manure, by bulk.					33⅓ p. ct.[3]	
		None.	5 p. ct.	10 p. ct.	15. p. ct.	20 p. ct.	Packed.	Loose.
Head lettuce,								
1898–1899..	1						6.11	5.15
1899–1900..	1	2.33	26.67	38.33	36.67	41.33	38.33	25.00
1900–1901..	1	1.53	3.03	4.69	2.68	2.85	2.29	2.11
Loose lettuce,								
1899–1900..	1	2.94	13.27	16.63	15.54	15.90	18.73	9.64
1900–1901..	1	1.38	3.05	3.65	3.85	3.06	2.25	1.80

[1] With the manure used, 5, 10, 15 and 20 per ct., by weight are equivalent to 11⅓, 22⅔, 34 and 45⅓ per ct., respectively, by bulk.
[2] All plants under these headings received 600 pounds acid phosphate per acre, 400 pounds sulphate of potash and 1,000 pounds dried blood, except where 33⅓ per ct. of manure was used.
[3] This is equivalent to 14.2 per ct. by weight for first crop on the clay loam and 14.7 per ct. for the first crop on sandy loam. No commercial fertilizers were used on these boxes.

Leaving out of consideration for the present those portions of soil which received 33 1-3 per ct. of manure without any commercial fertilizers, let us compare the rate of increase of the yield where none but commercial fertilizers were used with the rate where these were combined with manure.

From the table just given it appears that on the clay loam the use of 5 per ct. for the first crop gave an increase of 10.19 points over the yield with no manure; doubling the manure gave a

further increase of but 2.87 points; the 15 per ct. application gave an increase of but 0.38 point over the 10 per ct. and the 20 per ct. gave an increase of but 1.25 points over the 15 per ct. application.

In the next crop from the same soil the 5 per ct. application was followed by a very large increase in yield over that where commercial fertilizers were used alone; the 10 per ct. and 15 per ct. applications showed but little increase over the 5 per ct., while with the 20 per ct. application the yield actually dropped below that obtained with the 5 per ct.

In the following season the 5 per ct. application again showed a very large increase in yield over that where commercial fertilizers alone were used; the 10 per ct. application resulted in but slightly greater yield than that secured with the 5 per ct. application, the 15 per ct. showed a falling off in yield while with 20 per ct. it dropped still lower, being even less than the yield with the 5 per ct. application.

Similar cumulative effects of repeated applications of manure also appeared when loose lettuce was grown on the clay loam. Where the higher percentages of manure were used the later crops of lettuce showed an actual loss in yield.

On sandy loam the first crop of head lettuce showed an increased yield from the 5 per ct. and 10 per ct. applications of manure but higher percentages of manure showed a falling off in yield. With the next crop of lettuce the use of the higher percentages of manure was followed by successive increases in yield except that the yield with the 15 per ct. fell below that with the 10 per ct. application but the following season the highest yield was reached with the 10 per ct. application and the yields with the higher percentages of manure dropped below that of the 5 per ct. application. Results similar in kind if not in degree were obtained with the loose lettuce on sandy loam.

The data secured by the series of tests with nitrate of soda, sulphate of ammonia and the combination of dried blood and nitrate of soda confirm the testimony of the dried blood series on this point. They support the general conclusions that with soils similar to those used in these investigations:

1. Very much better crops of lettuce may be forced by using stable manure for enriching the soil than by using only commercial fertilizers of the kinds tested.

2. When the soil is used for the first time for forcing a crop of lettuce, an abundance of manure may be used with good results but where the use of manure is continued with the same soil year after year the optimum amount may be expected to decline towards the 5 per ct. rate. It is evident that the amount which it is economical to use varies with the character of the soil and of the manure and also with the relation of the prices for a fancy product to those paid for ordinary lettuce. For these reasons no definite recommendations can be made as to the amount of manure which it is profitable to use in forcing lettuce.

3. In forcing lettuce it is not good economy to make repeated applications of manure in excessive quantities to the same soil. Not only is manure thus wasted but the yield may be actually decreased.

WHY DO THE SMALLER AMOUNTS OF MANURE GIVE RESULTS BETTER THAN THOSE OBTAINED WHERE THE MANURE IS APPLIED IN EXCESSIVE QUANTITIES?

With the smaller amounts of manure applied to soils which had received an abundance of nitrogen, phosphoric acid and potash in commercial fertilizers the yield was much greater than it was on similarly treated soils without any manure, but where the manure was used in excessive quantities the yield, as has been shown above, dropped below that obtained with less manure. Why is this so? What factors of fertility does the manure introduce into the soil aside from the plant-food which it contains? The data bearing upon this question which have been obtained in carrying out the experiments under discussion have not all been presented in this account of the work. Other experiments which may throw light on this subject are now in progress. The discussion of this question will therefore be deferred till further data have been secured.

GINSENG CULTURE.*

N. O. BOOTH.

During the last few years we have received so many inquiries in regard to ginseng, its culture, its sale, and the prospects of its becoming a staple crop, that we issue this circular letter. We have not grown ginseng at this station and the information which is contained in this letter is gleaned from the various sources mentioned below.

The demand for ginseng comes from China, where it has been used for ages as a medicinal root. That it has some medicinal value is recognized by those who have investigated its properties, but it is nowhere a recognized remedy except in China. There it is a standard cure for all ills and equally efficacious as a preventive. The form of the root affects its value according to the Chinese; those roots resembling the human body being the most valuable. These facts are chiefly of importance as indicating the probable long continued demand for ginseng. Ancient customs and prejudices die out slowly even in this country, and China is not noted for sudden changes of thought or manner of living. Ginseng was first exported from America in the early part of the 18th century. In a few years the trade had grown to considerable proportions, when the exporters in this country ruined it by sending immature and imperfectly cured roots. For some years almost none was exported, and then the trade was gradually taken up again. Wild ginseng is becoming scarcer in the United States year by year; the amount exported is becoming less and the price higher. This is partially due to the fact that "Sang" hunters usually gather the root in summer before the plant has matured its seed, partially to the clearing out of the forests and pasturing of a large portion of that remaining. Virginia, West Virginia and Ontario, Canada, have passed laws to prevent the gathering of the roots out of season. The root itself is in better condition if gathered in the fall and does not shrink so much in drying.

Ginseng queries by prospective growers are along four lines: 1st. Is ginseng growing profitable? 2d. If profitable, where can I get seed and plants? 3d. How shall I raise and prepare the roots for market? 4th. Where can I sell them?

1st. As to the profits of ginseng growing, it is difficult to say how profitable the industry will eventually be to those who grow the roots for export alone. So far almost all growers have made the most of their money selling plants and seeds to others who wish to start plantations. Ginseng growing is something that requires little land but considerable work, and this work must be very carefully done. The work is light and might be done by women or children.

---

*Reprint of a circular.

2d. As to source of plant and seed supply, these can usually be secured cheaper from local growers or "Sang" hunters than from houses which make a business of handling the plants. If there be none of these "Sang" hunters in your locality it is usually best to write to all of the firms you know of for prices, for the price sometimes varies materially. Below are the names and addresses of some well-known growers: Geo. Stanton, Chinese Ginseng Farm, Summit Station, N. Y.; M. G. Harrison, Redford, Mo.; Harlan P. Kelsey, Tremont Building, Boston, Mass.; A. E. Leavitt, Houston, Mo.; Emanuel Lewis, Hemlock, Wis.; H. S. Seymour, Richland Center, Wis.; W. G. Palmer, Boydtown, Wis.; J. W. Sears, Sumerset, Ky.; American Ginseng Gardens, Rose Hill, N. Y.; G. F. Millard, Houston, Mo.; W. A. Bates, Cuba, N. Y. Seed costs at present from one to five dollars an ounce and plants from four to twenty dollars a hundred, but as indicated above both may frequently be secured much cheaper from local gatherers. If so secured, care must be taken that the roots be fresh from the ground and that the seeds be not thoroughly dried out as they will seldom grow in that condition.

3d. As to methods of culture, etc., Ginseng will not grow exposed to the direct rays of the sun. It grows naturally in deep woods and usually on north and east slopes. Consequently in cultivating ginseng either a spot which is naturally shaded must be chosen, or artificial shade given. Lath screens with a one-half inch space between laths are usually used for this purpose. They may be placed low and be removed for purposes of weeding, etc., or they may be fastened on posts six feet or more above the ground, so that a man can work under them. The latter method usually gives the best satisfaction. Ginseng likes a deep rich soil which does not dry out too readily. Clay loam with plenty of leaf mold or manure worked in will do very well. If small roots be planted they will give quicker results than seeds, but are somewhat more expensive. From the seed it takes from six to eight years to produce marketable roots. The grounds should be divided into beds not wider than four feet and as long as may be desired, with a narrow walk in between. Since all cultivation of ginseng is by hand beds wider than this are difficult of access. Roots should be planted from three to six inches apart each way, according to size. Seeds will not grow until eighteen months after ripening. During this period they may either be planted or mixed with moderately moist leaf mold and loam, and stored where they will not dry out, as once thoroughly dry the seed will not germinate. Seed may be sown in either spring or fall in rows three inches apart and one inch apart in the row and one-half inch deep. After the bed is planted it should be covered with litter or leaf mold about one inch deep to prevent drying out. This should be covered with light brush if there is danger of its blowing off. Weeds must be pulled out or rather cut off as they appear and the mulch renewed each fall when the tops die down. Great care must be taken not to loosen the plants in pulling weeds as this is usually fatal. Chickens must not be allowed access to the beds. One of the great drawbacks to ginseng growing is the danger of having the roots stolen. It is possible in a single night to lose the product of several years' work. On this account it is usually best to make the beds close to the house or some other point where they can be constantly watched. When the roots are large enough to dig they

should be dug in the fall, the smaller roots (less than two ounces) being replanted to increase in size. Great care must be taken in digging not to break the roots, for whole roots command a higher price than broken ones. As fast as they are dug shake off all loose earth and place the roots at once in water so that the earth remaining may not dry on them. Wash with a stiff brush or broom and plenty of water. For drying, Kains recommends a home-made drying oven made in the following manner: "Get a box large enough to cover the kitchen stove and deep enough to hold six or seven sliding shelves. Remove the bottom entirely. Make a hole in the top; take off one side and make a hinged door to fit in its place; make a number of shelves with bottoms of wire netting of about one-fourth inch mesh. In filling the shelves for the first time put the larger roots on the top shelves and the smaller upon the bottom ones, the lowest of which should be at least six inches above the top of the stove. Put the box upon the stove, but raised about half an inch above it, so as to prevent its bottom edges from becoming scorched and to insure a current of air through the shelves of roots. A few stout nails left projecting will accomplish this end." Use with a slow fire. "The roots upon the lowest shelf will ordinarily dry first. Take them out, fill the shelf with fresh roots and put in the dryer at the top after moving all the other trays down one notch toward the bottom." Rub off all the small fibrous roots when dried sufficiently to be brittle and return the large roots to dryer. These trimmings are frequently sold to local drug stores for people who chew ginseng. "When the roots have become dry as a bone and are perfectly cool, put them in paper sacks or clean boxes to await shipment."

4th. Sale of the roots: In some parts of the State there are buyers already on the ground, but generally it is necessary to ship to some wholesale house. Write to Wm. Eisenhauer & Co., 378-380 West Broadway, New York; Samuel Wells & Co., Cincinnati, Ohio; Felt Butler Co., 83 Spring street, New York. Ginseng now brings from \$2.50 to \$6 or \$7 a pound, depending on the quality. The price is rising each year.

Considerable literature has been published from time to time on the subject of ginseng. Besides the prospectuses of those selling the plants, at least two books and three bulletins have been published. These are as follows: "Ginseng," by Maurice G. Kains, Orange Judd & Co., publishers. A book on ginseng, title unknown, by M. G. Harrison, Redford, Mo. The Pennsylvania State Department of Agriculture has issued a bulletin (No. 27) on this subject. The United States Department of Agriculture has published a bulletin on "American Ginseng." (Botanical division No. 16.) The Kentucky Experiment Station of Lexington, Ky., has issued a bulletin (78) "Ginseng, Its Nature and Culture." The cheapest and perhaps the best way to obtain information on this subject is from those who have experimented in growing it, if there be any in your locality. Most of the parties who sell roots and seeds issue printed directions which are included with sales.

REPORT

OF

INSPECTION WORK.

W. H. JORDAN, *Director.*
L. L. VAN SLYKE, *Chemist.*
C. G. JENTER, *Assistant Chemist.*
W. H. ANDREWS, *Assistant Chemist.*

TABLE OF CONTENTS.

INSPECTION OF FEEDING STUFFS.*

W. H. JORDAN AND C. G. JENTER.

SUMMARY.

The report given herewith of the inspection of feeding stuffs comprises the following:

(1) List of brands licensed in the State of New York for the year 1901.

(2) Analyses of samples collected late in 1900.

(3) Analyses of samples collected in 1901.

(4) Comments on the facts shown by the inspection.

(5) Suggestions to dealers.

(6) Suggestions to purchasers.

FEEDING STUFFS LICENSED IN 1901.

Ninety-two manufacturers have complied with the law by registering the guaranteed composition of 126 brands of feeding stuffs and paying the required license fees therefor.

The brands named in the following list are those which it has been legal to sell in New York during 1901. Doubtless these cover a very large proportion of the by-product feeding stuffs consumed in New York.

---

*A reprint of Bulletin No. 198.

TABLE I.—MANUFACTURERS AND IMPORTERS WHO HAVE COMPLIED WITH THE NEW YORK FEEDING STUFFS LAW FOR THE YEAR 1901 WITH A LIST OF BRANDS SO GUARANTEED AND THE GUARANTEES.

License number.	Manufacturer or jobber. Name.	Address.	Name of feed.	Guaranteed. Protein. Per ct.	Fat. Per ct.
119	Acme Mills Co.,	Olean,	Acme feed,	9.70	4.41
163	Adikes, J. & T.,	Jamaica,	Ground feed,	8.75	3.00
122	Akron Cereal Co.,	Akron, O.,	Boss C. and O. feed,	7.94	4.18
	Akron Cereal Co.,	Akron, O.,	Royal oat feed,	8.25	4.14
128	American Cereal Co.,	Chicago, Ill.,	Quaker dairy feed,	12.03	2.50
	American Cereal Co.,	Chicago, Ill.,	Victor corn and oat feed,	8.23	3.00
	American Cereal Co.,	Chicago, Ill.,	Schumacher's stock feed,	10.79	3.28
	American Cereal Co.,	Chicago, Ill.,	Buckeye wheat feed,	16.21	4.48
	American Cereal Co.,	Chicago, Ill.,	Vim oat feed,	6.30	2.58
	American Cereal Co.,	Chicago, Ill.,	X oat feed,	6.30	2.58
	American Cereal Co.,	Chicago, Ill.,	Prime cottonseed meal,	43.0	9.0
88	American Cotton Oil Co.,	New York,	American poultry feed,	13.65	3.96
138	American Linseed Co.,	New York,	Oil meal, O. P.,	32–36	5–7
84	American Milling Co.,	Detroit, Mich.,	Hominy feed,	9.89	7.06
94	American Malting Co.,	Chicago, Ill.,	Sucrene dairy feed,	16.50	3.50
104	Archer Starch Co.,	Chicago, Ill.,	Gluten feed,	25.50	3.25
170	Armour Fertilizer Works,	Chicago, Ill.,	Meat meal,	65–68	12–14
	Armour Fertilizer Works,	Chicago, Ill.,	Poultry bone,	24–26	5–6
87	Atlas Distillery,	Peoria, Ill.,	Atlas gluten meal,	36.0	11.5
89	Bagley, G. W., & Son,	Peekskill,	Mixed feed,	12.44	4.65
105	Banner Food Co.,	Auburn,	Banner stock food,	25.0	5.0
107	Barwell, J. W.,	Waukegan, Ill.,	Blatchford's calf meal,	26.0	5.0
172	Biles Co., The J. W.,	Cincinnati, O.,	Distiller's dried grains,	33.0	11.0
82	Bishopp Hominy Co.,	Sheldon, Ill.,	Hominy chop,	10.13	7.60
113	Bowker Fertilizer Co.,	Boston, Mass.,	Bowker's animal meal,	30.0	5.0
	Bowker Fertilizer Co.,	Boston, Mass.,	Bowker's beef scrap,	30.0	20.0
101	Brooks-Griffiths Co.,	Minneapolis, Minn.,	Royal mixed feed,	16.61	5.48
154	Cadosia Mills,	Cadosia,	Crescent corn and oat feed,	8.34	2.60
127	Cerealine Mfg. Co.,	Indianapolis, Ind.,	Cerealine feed No. 1,	7.88	5.99
	Cerealine Mfg. Co.,	Indianapolis, Ind.,	Cerealine feed No. 2,	10.82	8.03

169	Cerealine Mfg. Co.,	Indianapolis, Ind.,	Cerealine germ oil cake,	15.63	8.0
114	Chapin & Co.,	Buffalo,	Green diamond hominy feed,	11.0	8.0
	Chapin & Co.,	Buffalo,	Green diamond chop feed,	10.25	3.50
	Chapin & Co.,	Buffalo,	Cottonseed meal,	43.0	9.0
95	Cleveland Milling Co., Ltd.,	Cleveland, O.,	B chop,	9.58	5.42
	Cleveland Milling Co., Ltd.,	Cleveland, O.,	C chop,	9.13	3.27
141	Commercial Milling Co.,	Detroit, Mich.,	Dandy ground corn and oat feed prov.,	10.81	9.72
111	Crescent Milling Co.,	Allegany,	Chop feed,	8.40	3.54
115	Crittenden, M. L.,	Buffalo,	Sterling provender,	8.82	5.55
93	Crow & Williams,	Ossining,	Mixed feed,	9.0	4.0
98	Darling & Co.,	Chicago, Ill.,	Beef scraps,	55–65	15–20
	Darling & Co.,	Chicago, Ill.,	Beef meal,	55–65	10–15
147	Decatur Cereal Mill Co.,	Decatur, Ill.,	Ground hominy chop,	11.83	9.18
148	Diamond Elevator and Milling Co.,	Minneapolis, Minn.,	O. O. feed,	10.51	5.75
	Diamond Elevator and Milling Co.,	Minneapolis, Minn.,	Hominy feed,	11.16	5.52
129	Diamond Mills,	Buffalo,	Diamond C. and O. feed,	9.44	4.78
134	Ellicottville Milling Co.,	Ellicottville,	Chop feed,	8.20	4.40
120d	Ellsworth & Co.,	Buffalo,	De Fi corn and oat feed,	8.3	3.0
99	Empire Mills,	Olean,	Empire feed,	7.63	2.97
156	Evans, C. H., & Sons,	Hudson,	Malt sprouts,	28.44	0.46
164	Everett & Treadwell,	Kingston,	C. O. & W. feed,	11.50	3.50
85	Finn's, H., Sons,	Syracuse,	Ground beef cracklings,	50.68	20.66
140	Glucose Sugar Refining Co.,	Chicago, Ill.,	Chicago gluten meal,	38.0	3.2
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Fancy corn bran,	14.0	2.5
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Germ oil meal,	25.5	10.5
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Diamond gluten feed,	28.5	3.3
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Buffalo gluten feed,	28.5	3.3
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Davenport gluten feed,	28.5	3.3
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Marshalltown gluten feed,	28.5	3.3
124	Harding, Geo. L.,	Binghamton,	Ground beef scraps,	42.0	38.0
	Harding, Geo. L.,	Binghamton,	Meat meal,	49.0	19.0
112	Hauenstein & Co.,	Buffalo,	Linseed meal, O. P.,	40.96	8.65

TABLE 1.—*Continued.*

License number.	Manufacture or jobber. Name.	Address.	Name of feed.	Guaranteed. Protein.	Fat.
				Per ct.	*Per ct.*
116	Hayt, S. T.,	Corning,	Corn and oats,	10.43	4.00
155	Heath, H. R., & Sons,	Fort Dodge, Iowa,	Yankee corn and oat feed,	8.96	4.33
167	Hodgman, W. S., & Co.,	Painted Post,	Corn and oat feed,	9.69	3.88
120	H. O. Company,	Buffalo,	H. O. Co.'s horse feed,	12.0	4.5
	H. O. Company,	Buffalo,	H. O. Co.'s dairy feed,	18.0	4.5
	H. O. Company,	Buffalo,	H. O. Co.'s poultry feed,	17.0	5.5
136	Hotton Bros.,	Portville,	Common feed,	8.38	4.85
110	Hudnut Co.,	Terre Haute, Ind.,	Hominy feed,	12.85	8.52
174	Hudnut Co.,	Terre Haute, Ind.,	Maizeline feed,	10.42	9.03
106	Hunter Bros.,	St. Louis, Mo.,	Cottonseed meal,	43.0	9.0
	Hunter Bros.,	St. Louis, Mo.,	Hominy feed,	11.02	7.70
161	Hunter Bros.,	St. Louis, Mo.,	Linseed meal.	34.0	6.5
	Hunter Bros.,	St. Louis, Mo.,	Ned corn and oat chop,	9.0	5.0
125	Husted Milling and Elevator Co.,	Buffalo,	Monarch chop feed,	10.40	3.27
171	Illinois Sugar Refining Co.,	Pekin, Ill.,	Pekin gluten feed,	27.5	3.3
149	Imperial Grain and Milling Co.,	Toledo, O.,	Special hominy feed,	7.87	5.67
83	Independent Cottonseed Oil Co.,	Memphis, Tenn.,	Star brand cottonseed meal,	42–45	8–12
96	Indianapolis Hominy Mills,	Indianapolis, Ind.,	Hominy feed,	11.10	10.47
92	Kelloggs & Miller,	Amsterdam,	Linseed oil meal,	36.70	7.83
121	Kellogg, Spencer,	Buffalo,	S. K. oil meal,	37.56	6.28
108	Kentucky Milling Co.,	Henderson, Ky.,	Jersey mixed feed,	11.56	3.65
173	Knickerbocker Milling and Grain Co.,	Albany,	Champion,	9.92	4.01
159	Lapham & Parks,	Glens Falls,	Common feed,	7.5	3.25
130	Lederer, J., & Co.,	New Haven, Conn.,	Best poultry food,	51–55	10–16
175	Lowell Fertilizer Co.,	Boston, Mass.,	Bone and meat meal,	50.0	10.0
91	Mann Bros. & Co.,	Buffalo,	Oil meal,	35.15	7.05
144	Mapes, O. W.,	Middletown,	Mapes' balanced ration for poultry,	14.0	4.5
126	McCoy & Best,	Peekskill,	Evaporated bone and meat meal,	41.40	19.75
97	Miami Maize Co.,	Toledo, O.,	Hominy feed,	10.93	7.05

166	Midland Linseed Oil Co.,	Minneapolis, Minn.,	Pure O. P. ground linseed cake,	32–38	5.75–9.0
109	Mohawk Milling and Malting Co.,	Mohawk,	Malt sprouts,	23.95	3.93
152	Mueller, E. P.,	Chicago, Ill.,	Dried grains,	23.85	6.13
	Mueller, E. P.,	Chicago, Ill.,	Barley, or malt, sprouts,	26.25	1.01
103	Muscatine Oat Meal Co.,	Muscatine, Ia.,	Friend's concentrated dairy feed,	10.9	3.7
143	National Starch Co.,	New York,	Gluten feed,	22.9	2.3
	National Starch Co.,	New York,	King gluten meal,	35.0	3.5
158	Nester, S. K.,	Geneva,	Malt sprouts,	25.0	2.0
160	Newport Milling Co.,	Newport, Ind.,	Hominy feed,	11.4	4.74
157	Norton & Co.,	Chicago, Ill.,	Standard oat feed,	5.5	4.0
90	Oliver & Bolender,	Olean,	Chop feed,	8.13	4.59
139	Oliver, David,	Joliet. Ill.,	Durham corn and oat feed,	9.46	3.92
168	Oneonta Milling Co.,	Oneonta,	Corn and oat provender,	8.75	3.50
	Oneonta Milling Co.,	Oneonta,	Arrow corn and oat feed,	9.00	3.75
	Oneonta Milling Co.,	Oneonta,	Monarch horse feed,	13.00	5.75
133	Patent Cereals Co.,	Geneva,	Hominy feed,	11.46	9.30
146	Personius, D. V., & Son,	Waverly,	Corn and oat feed,	7.94	4.18
151	Pfeffer Milling Co.,	Lebanon, Ill.,	Hominy feed meal,	11.57	9.93
*123	Pillsbury-Washburne Flour Mills Co., Ltd.,	Minneapolis, Minn.,	Pillsbury's concentrated dairy feed,	7.09	2.85
132	Pope, Chas., Glucose Co.,	Chicago, Ill.,	Cream gluten meal,	34.12	3.20
	Pope, Chas., Glucose Co.,	Chicago, Ill.,	Corn bran,	9.44	1.60
150	Rankin, M. S., & Co.,	Louisville, Ky.,	Star distillers' dried grains,	30.0	9.5
176	Rankin, M. S., & Co.,	Louisville, Ky.,	Jersey malt sprouts,	26.25	1.01
135	Rathbun-Sawyer Co.,	Oneida,	Chop feed,	10.5–13.5	3.0–4.5
153	Romaine, DeWitt,	Hackensack, N. J.,	Boiled beef and bone,	45.0	15.0
102	Shellabarger Mill and Elevator Co.,	Decatur, Ill.,	Shellabarger's hominy feed,	11.14	9.02
137	Staples, A. S.,	Rondout,	Arcade mills mixed feed,	10.42	8.76
118	Streeter, L. L., & Sons,	Johnstown,	Common feed,	8.78	5.23
145	Suffern, Hunt & Co.,	Decatur, Ill.,	Hominy chop,	11.02	7.70
162	Terwilliger, C. A.,	Niagara Falls,	Niagara chop,	10.42	4.83
86	Toledo Elevator Co.,	Toledo, O.,	Star brand feed,	7.87	5.67

TABLE I.—*Concluded.*

License number.	Manufacturer or jobber.		Name of feed.	Guaranteed.	
	Name.	Address.		Protein.	Fat.
				Per ct.	*Per ct.*
165	Union Linseed Co.,	Troy,	Cow brand oil meal,	22.09	6.32
100	U. S. Frumentum Co.,	Detroit, Mich.,	Frumentum hominy feed,	10.15	6.63
142	U. S. Sugar Refinery,	Waukegan, Ill.,	Waukegan gluten feed,	27.38	3.39
117	Victor Milling Co.,	Springville.	Golden chop.	9.17	5.84
131	Wright. M. M., & Co.,	Danville, Ill.,	Wright's hominy feed,	10.93	8.00

* Changed to "Great western concentrated dairy feed," manufactured by Great Western Cereal Co.

The above list of brands may be classified as follows:

Cottonseed meal	4 brands.
Linseed meal	8 "
Gluten meal	4 "
Gluten feed	8 "
Germ oil meal or cake	2 "
Malt sprouts	5 "
Brewer's grains	1 "
Distillery wastes	3 "
Corn bran	2 "
Hominy feed or chops	16 "
Meat and bone feeds (poultry mostly)	13 "
Feeds mostly compounded from several manufacturing offals, in most cases bearing special proprietary names	60 "
	126 brands.

The striking fact about this list is the large proportion of specially compounded feeding stuffs, the ingredients of which are in many cases standard cattle foods mixed with materials of less value.

ANALYSES OF SAMPLES OF FEEDING STUFFS COLLECTED DURING 1900-1901.

In the tables which follow may be seen the percentages of protein and fat, and in some cases of crude fiber, in the samples collected. Only determinations of protein and fat are required, but the proportion of crude fiber has been ascertained as an aid in deciding as to the use of oat hulls in a certain class of mixtures.

The number and character of the samples taken may be seen in the succeeding classified table.

Table II.—Number and Character of Samples.

Kind.	Samples, fall of 1900 — No. of samples.	Samples, fall of 1900 — No. of brands.	Samples, winter 1901. — No. of samples.	Samples, winter 1901. — No. of brands.
Cottonseed meal	3	2	13	8
Linseed meal	7	5	12	9
Gluten meal	1	1	2	1
Gluten feeds	10	6	17	5
Germ oil meal	1	1	2	1
Special gluten (?)	1	1		
Malt sprouts	1	1	1	1
Proprietary feeds (mixed)	42	32	54	27
Corn bran	2	2	7	3
Hominy	15	13	18	13
Poultry foods	9	6	18	10
Offals from milling wheat and rye	11	7	16	10
Ground grains, mostly mixed corn and oats	21	21	13	13
Totals	124	98	173	101

Summary.

Fall 1900—	Manufacturers	78	Winter 1901— Manufacturers	70
	Brands	98	Brands	101
	Samples	124	Samples	173

TABLE III.—SAMPLES OF FEEDING STUFFS

Collection No.	Name and address of manufacturer or jobber.	Sampled at
202	American Cotton Oil Co., New York,	Delhi, Dean & Bramley,
216	American Cotton Oil Co., New York,	Delhi, Penfield Milling Co.,
174	Chapin & Co., St. Louis, Mo.,	Lockport, John T. Darrison,
165	Hauenstein & Co., Buffalo,	Brockport, C. E. Shafer,
167	Hauenstein & Co., Buffalo,	Albion, Woods & Sprague,
181	Kelloggs & Miller, Amsterdam,	Mohawk, Mohawk Milling & Malting Co.,
148	Kellogg, Spencer, Buffalo,	*
169	Mann Bros. & Co., Buffalo,	Lockport, James V. Rignel,
124	Mayflower Mills, Fort Wayne, Ind.,	Corning, W. M. Killigrew,
131	Mayflower Mills, Fort Wayne, Ind.,	Belmont, Hood & Bradley,
152	National Starch Co., New York,	Buffalo, National Starch Co.,
209	Cullen, Andrew, Co., New York,	Delhi, Gleason & Kiff,
126	Glucose Sugar Refining Co., Chicago, Ill.,	Hornellsville, Steph. Hollands,
201	Glucose Sugar Refining Co., Chicago, Ill.,	Delhi, Dean & Bramley,
134	Glucose Sugar Refining Co., Chicago, Ill.,	Portville, Hotton Bros.,
164	Glucose Sugar Refining Co., Chicago, Ill.,	Brockport, C. E. Shafer,
151	National Starch Co., New York,	Buffalo, National Starch Co.,
156	National Starch Co., New York,	Springville, B. Chaffee,
840	National Starch Co., New York,	Florida, Roe Bros.,
192	National Starch Co., New York,	Ossining, Crow & Williams,
217	Oneonta Milling Co., Oneonta,	Delhi, Coöperative Store Co.,
139	U. S. Sugar Refinery, Waukegan, Ill.,	East Aurora, Griggs & Ball,
141	Glucose Sugar Refining Co., Chicago, Ill.,	Buffalo, Chapin & Co.,
154	Barwell, J. W., Waukegan, Ill.,	Springville, B. Chaffee,
215	Barwell, J. W., Waukegan, Ill.,	Delhi, Penfield Milling Co.,
180	Mohawk Milling and Malting Co., Mohawk,	*
129	American Cereal Co., Chicago, Ill.,	Alfred, W. C., Burdick & Co.,
183	American Cereal Co., Chicago, Ill.,	Roundout, F. H. Griffiths,
200	Arcade Mills, Kingston,	Stamford, D. C. Hoagland,
205	Brooks Griffith Co., Minneapolis, Minn.,	Delhi, Dean & Bramley,
210	Brooks Griffith Co., Minneapolis, Minn.,	Delhi, Gleason & Kiff,
213	Brooks Griffith Co., Minneapolis, Minn.,	Delhi, Gleason & Kiff,
214	Kaufmann Milling Co., St. Louis, Mo.,	Delhi, Penfield Milling Co.,
211	Simpson Hendee & Co., New York,	Delhi, Gleason & Kiff,
212	Simpson Hendee & Co., New York,	Delhi, Gleason & Kiff,
153	The H. O. Co., Buffalo,	Buffalo, Schen Bros.,
207	The H. O. Co., Buffalo,	Delhi, Gleason & Kiff,

COLLECTED DURING THE FALL OF 1900.

Collection No.	Name of feed.	Protein. Found. Per ct.	Protein. Guaranteed. Per ct.	Fat. Found. Per ct.	Fat. Guaranteed. Per ct.	Crude fiber found. Per ct.	Price per ton.
202	Prime cotton seed meal,	45.8	43.0	9.3	9.0		$27.00
216	Prime cotton seed meal,	45.1	43.0	11.8	9.0		
174	Cotton seed meal,	43.2	43.0	9.1	9.0		
165	Linseed meal, O. P.,	35.6	39.62	7.8	8.53		33.00
167	Linseed meal, O. P.,	35.1	39.62	7.9	8.53		35.00
181	Linseed oil meal,	36.1	36.70	9.4	7.83		35.00
148	S. K. oil meal,	33.7	35.94	12.8	5.04		
169	Oil meal,	36.7	35.15	7.8	7.05		32.00
124	[1]Mayflower linseed meal,	17.6	32.36	4.3	5.7	20.7	35.00
131	Mayflower linseed meal,	16.6	32.36	4.5	5.7	22.6	
152	King gluten meal,	36.4	32.6	2.7	3.7		
209	[1]Daisy gluten feed,	19.4	——	2.5	——	8.9	19.00
126	Buffalo gluten feed,	25.6	27.0	5.6	3.3		
201	Davenport gluten feed,	26.7	27.0	5.3	3.3		22.00
134	Diamond gluten feed,	28.7	27.0	3.6	3.3		19.00
164	Diamond gluten feed,	26.9	27.0	2.8	3.3		21.00
151	Gluten feed,	20.9	21.2	2.7	2.9		
156	Gluten feed,	23.1	21.2	3.3	2.9		
s40	Gluten feed,	19.0	21.2	2.4	2.9	3.9	
192	Gluten feed,	24.2	21.2	4.0	2.9		22.00
217	[1]Special gluten,	14.8	——	3.3	——	11.7	20.50
139	Waukegan gluten feed,	26.8	27.38	3.6	3.39		20.00
141	Germ oil meal,	23.4	25.0	7.8	10.5		
154	Blatchfords' calf meal,	24.4	27.12	4.7	6.80		70.00
215	Blatchfords' calf meal,	25.3	27.12	4.6	6.80		70.00
180	Malt sprouts,	22.7	23.95	4.9	3.93		15.00
129	Buckeye wheat feed,	18.0	16.21	5.4	4.48		20.00
183	Buckeye wheat feed,	18.3	16.21	4.8	4.48	6.7	20.00
200	[3]Mixed feed,	17.1	——	10.3	——	8.8	20.00
205	Royal mixed feed,	17.4	16.61	4.9	5.48	7.0	20.00
210	Royal mixed feed,	17.8	16.61	5.4	5.48		20.00
213	[4]Royal mixed feed,	16.3	16.61	4.8	5.48	9.1	20.00
214	[3]Kauffmann's mixed feed,	18.3	——	4.3	——	7.3	20.00
211	Angola mixed feed,	16.8	16.61	5.0	5.48	8.1	20.00
212	Angola mixed feed,	17.6	16.61	5.3	5.48	9.4	20.00
153	H. O. Co.'s dairy feed,	18.6	18.0	4.0	4.5	13.5	18.00
207	H. O. Co.'s dairy feed,	18.1	18.0	4.3	4.5	13.5	23.00

TABLE III.

Collection No.	Name and address of manufacturer or jobber.	Sampled at
150	The H. O. Co., Buffalo,	Buffalo, C. E. Perry & Co.,
178	The H. O. Co., Buffalo,	Mohawk, Mohawk Milling and Malting Co.,
196	The H. O. Co., Buffalo,	Kingston, Everett & Treadwell,
206	The H. O. Co., Buffalo,	Delhi, Gleason & Kiff,
172	American Cereal Co., Chicago, Ill.,	Lockport, W. E. & H. K. Whicker,
130	American Cereal Co., Chicago, Ill.,	Alfred, W. C. Burdick & Co.,
159	American Cereal Co., Chicago, Ill.,	Salamanca, E. K. Abbott,
155	Chapin & Co., Buffalo,	Springville, B. Chaffee.
218	Diamond Elevator and Milling Co., Minneapolis, Minn.,	Delhi, Coöperative Store Co.,
184	Hudnut Co., Terre Haute, Ind.,	Rondout, F. H. Griffiths,
187	Indianapolis Hominy Mills, Indianapolis, Ind.,	Rondout, A. S. Staples,
199	Miami Maize Co., Toledo, O.,	Stamford, D. C. Hoagland,
203	Miami Maize Co., Toledo, O.,	Delhi, Dean & Bramley,
144	Oriental Flour Co., Danville, Ill.,	Buffalo, John G. Heinold,
186	Patent Cereals Co., Geneva,	Rondout, A. S. Staples,
142	Pfeffer Milling Co., Lebanon, Ill.,	Buffalo, J. H. Rodebaugh,
140	Rodebaugh, J. H., Buffalo,	East Aurora, E. E. Godfrey,
191	Shellabarger Mill & Elevator Co., Decatur, Ill.,	Peekskill, C. S. Horton & Sons,
204	Shellabarger Mill & Elevator Co., Decatur, Ill.,	Delhi, Dean & Bramley,
143	U. S. Frumentum Co., Detroit, Mich.,	Buffalo, J. H. Rodebaugh,
197	Wiedler, S. W., & Co., Cincinnati, O.,	Kingston, Wilson & Wolven,
127	Wright, M. M., & Co., Danville, Ill.,	Hornellsville, Steph. Hollands,
173	Chapin & Co., Buffalo,	Lockport, John T. Darrison,
177	Glucose Sugar Refining Co., Chicago, Ill.,	Oneida, Rathbun Sawyer Co.,
137	Acme Mills Co., Olean,	[2]
198	Akron Cereal Co., Akron, O.,	Kingston, Chas. F. Gray,
128	American Cereal Co., Chicago, Ill.,	Alfred, W. C. Burdick & Co.,
163	American Cereal Co., Chicago, Ill.,	Brockport, C. E. Shafer,
168	American Cereal Co., Chicago, Ill.,	Albion, Woods & Sprague,
170	American Cereal Co., Chicago, Ill.,	Lockport, James D. Rignel,
121	American Cereal Co., Chicago, Ill.,	Corning, S. T. Hayt,
189	Bagley, G. W., & Son, Peekskill,	[2]
190	Cerealine Mfg. Co., Indianapolis, Ind.,	Peekskill, G. W. Bagley & Son,
160	Cleveland Milling Co., Cleveland, O.,	Little Valley, Geo. W. Griffiths,
135	Crescent Milling Co., Allegany,	[2]
145	Crittenden, M. L., Buffalo,	[2]
146	Crittenden, M. L., Buffalo,	[2]

—Continued.

Collection No.		Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude fiber found.	Price per ton.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
150	H. O. Co.'s horse feed,	12.6	12.0	3.8	4.5	9.4	$20.00
178	H. O. Co.'s horse feed,	12.3	12.0	3.8	4.5	10.9	22.00
196	H. O. Co.'s horse feed,	13.3	12.0	4.8	4.5	10.9	23.00
206	H. O. Co.'s horse feed,	12.7	12.0	3.7	4.5	8.9	22.00
172	Quaker dairy feed,	13.0	12.03	3.4	2.50	16.5	18.00
130	Schumacher's stock feed,	11.4	10.79	5.2	3.28	12.1	20.00
159	Schumacher's stock feed,	10.7	10.79	4.7	3.28	12.4	21.00
155	[1]Hominy, "Mohawk"	10.8	——	8.4	——		18.00
218	[5]Hominy feed,	10.3	——	7.1	——		19.00
184	Hominy feed,	11.0	12.85	9.2	8.52		19.00
187	Hominy feed,	11.6	11.10	8.9	10.47		18.00
199	Hominy feed,	10.9	10.93	10.4	7.05		20.00
203	Hominy feed,	10.4	10.93	7.6	7.05		18.50
144	Hominy feed,	10.8	11.06	7.0	9.85		
186	Hominy feed,	12.1	11.64	9.9	8.03		18.00
142	Hominy feed,	11.4	10.00	9.5	8.00		
140	[5]Hominy feed,	11.0	10.15	8.8	6.63		17.50
191	Hominy feed,	11.5	10.76	10.4	8.64		19.50
204	Hominy feed,	12.0	10.76	8.9	8.64		19.50
143	Hominy feed,	11.8	10.15	9.9	6.63		
197	Hominy feed,	11.3	9.98	9.0	8.33		18.00
127	Hominy feed,	11.3	10.93	9.8	8.00		
173	[5]Sugar corn feed,	13.1	——	3.5	——		17.00
177	Sugar corn feed,	13.5	13.5	3.6	3.0		18.00
137	Acme feed,	8.6	9.70	4.6	4.41	7.3	19.00
198	Corn and oat chop, No. 1,	10.8	7.94	6.7	4.18	12.1	18.35
128	Victor corn and oat feed,	8.9	8.23	3.8	3.00	10.8	18.00
163	Victor corn and oat feed,	9.2	8.23	5.1	3.00	11.9	18.00
168	Victor corn and oat feed,	9.2	8.23	4.6	3.00	10.6	17.50
170	Victor corn and oat feed,	9.1	8.23	4.4	3.00	9.9	18.00
121	Vim oat feed,	5.1	6.30	1.9	2.58	29.6	16.00
189	Mixed feed,	13.3	12.44	7.0	4.65	5.8	22.00
190	Cerealine feed, No. 2,	12.4	10.31	10.1	8.62	2.4	21.00
160	[1]C. chop feed,	8.9	9.13	4.2	3.27	4.8	19.00
135	Chop feed,	8.0	8.40	3.9	3.58	8.9	18.00
145	[1]Sterling corn meal,	8.4	11.12	4.3	6.46	6.4	
146	Sterling provender,	7.6	8.82	3.2	5.55	14.9	

TABLE III

Collection No.	Name and address of manufacturer or jobber.	Sampled at
147	Crittenden, M. L., Buffalo,	[2]
194	Crow & Williams, Ossining,	[2]
149	Diamond Mills, Buffalo,	[2]
158	Ellicottville Milling Co., Ellicottville,	[2]
122	Empire Mills, Olean,	Corning, W. M. Killigrew,
136	Empire Mills, Olean,	[2]
120	Hayt, S. T., Corning,	[2]
193	Heath, H. R., & Sons, Fort Dodge, Ia.,	Ossining, Crow & Williams,
133	Hotton Bros., Portville,	[2]
195	Kentucky Milling Co., Henderson, Ky.,	Kingston, Everett & Treadwell,
179	Mohawk Milling & Malting Co., Mohawk,	[2]
138	Oliver & Bolender, Olean,	[2]
132	Phelps & Sibley, Cuba,	Friendship, Graham & Robinson,
125	Sanborne & McClave, Elmira,	Hornellsville, Simmons & Howell,
185	Staples, A. S., Rondout,	[2]
182	Streeter, L. L., & Sons, Johnstown,	[2]
157	Victor Milling Co., Springville,	[2]
s 38	Adams, E. M., Franklinville,	[2]
s 42	Saunders, G. P., Dunkirk,	[2]
s 19	Bidleman & Rowley, Medina,	[2]
s 22	Gage, W. G., & Co., Fulton,	Adams, I. M. Bateman,
s 23	Osborn, W. H., Mexico,	[2]
s 18	Acme Mills, Olean,	[2]
s 10	Adams, E. M., Franklinville,	[2]
s 14	Amity Roller Mills, Belmont,	[2]
s 43	Benson, A. T., Cattaraugus,	[2]
s 20	Bidleman & Rowley, Medina,	[2]
s 24	Cleveland Milling Co., Cleveland, O.,	Salamanca, E. R. Abbott,
s 15	Dean & Spring Mfg. Co., Franklinville,	[2]
s 21	Fitzpatrick & Weller, Ellicottville,	[2]
s 35	Godfrey, E. E., East Aurora,	[2]
s 13	Griggs & Ball, East Aurora,	[2]
s 11	Oliver & Bolender, Olean,	[2]
s 16	Saunders, G. P., Dunkirk,	[2]
s 41	Sowl Milling Co., Salamanca,	[2]
s 34	True & Young, Cattaraugus,	[2]
[1]s 12	Hollands, Stephen, Hornellsville,	[2]
[1]s 17	Berger, Anderson Co., Milwaukee, Wis.,	Cattaraugus, A. T. Benson,
s 39	Hollands, Stephen, Hornellsville,	[2]
s 36	Fitzpatrick & Weller, Ellicottville,	[2]
s 37	Weinhold, G., Buffalo,	Springville, Springville Roller Flour Mills,
123	American Cereal Co., Chicago, Ill.,	Corning, W. M. Killigrew,
171	American Cereal Co., Chicago, Ill.,	Lockport, James O. Rignel,
162	H. O. Co., Buffalo,	Dunkirk, J. W. O'Brien & Co.,
208	H. O. Co., Buffalo,	Delhi, Gleason & Kiff,
119	Bowker Fertilizer Co., Boston, Mass.,	Medina, S. P. Blood & Co.,
166	Bowker Fertilizer Co., Boston, Mass.,	Brockport, C. E. Shafer,
175	Finn's, H., Sons, Syracuse,	[2]
188	McCoy & Best, Peekskill,	[2]
s 33	Preston Fertilizer Co., Brooklyn,	Goshen, Conklin & Cummins,

—*Concluded.*

Collection No.	Name of feed.	Protein. Found.	Protein. Guaranteed.	Fat. Found	Fat. Guaranteed.	Crude fibre found.	Price per ton.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
147	"999,"	10.8	10.27	3.8	4.43	11.7	
194	C. and W. mixed feed,	10.4	10.0	6.5	4.5	9.5	$21.00
149	Diamond corn and oat feed,	7.9	9.44	3.2	4.78	10.6	
158	Chop feed,	8.1	10.38	4.1	4.14	8.4	18.00
122	Empire feed,	8.4	7.63	3.8	2.97	6.1	19.00
136	Empire feed,	8.2	7.63	3.8	2.97	8.1	20.00
120	Corn and oat chop feed,	11.3	10.00	5.8	4.00	8.1	19.00
193	Yankee corn and oat feed,	7.1	8.96	2.5	4.33	15.6	18.50
133	Common feed,	10.1	8.38	5.2	4.85	9.9	18.00
195	Jersey mixed feed,	14.9	11.59	3.9	3.48	13.4	19.50
179	Corn and oat chop,	11.8	6.52	3.9	2.52	6.2	
138	Chop feed,	9.4	8.13	6.1	4.59	7.8	19.00
132	[3]Corn and oat chop,	10.5		4.6		4.2	22.00
125	[1]Diamond mills special chop,	9.9	——	4.3	——	1.6	22.00
185	Arcade mixed feed,	11.5	10.42	5.5	5.86	6.7	18.00
182	Common feed,	8.6	8.78	3.6	5.23	7.3	19.40
157	Golden chop,	8.0	9.17	3.9	5.84	10.8	18.00
s 38	Corn meal, No. 2,	9.4		4.4		2.0	
s 42	Corn meal, No. 2,	10.1		3.9		1.9	
s 19	Oats, ground,	12.9		7.6		9.5	
s 22	Oats, ground,	11.2		3.4		9.6	
s 23	Oats, ground,	11.1		2.9		10.7	
s 18	Corn and oats,	9.9		5.6		3.7	
s 10	Corn and oats,	9.4		3.5		7.6	
s 14	Corn and oats,	10.1		3.3		6.0	
s 43	Corn and oats,	10.9		4.5		7.3	
s 20	Corn and oats,	10.6		6.2		4.9	
s 24	Corn and oats,	10.3		5.0		5.8	
s 15	Corn and oats,	10.3		4.7		5.5	
s 21	Corn and oats,	10.5		5.6		4.8	
s 35	Corn and oats,	12.3		3.2		6.5	
s 13	Corn and oats,	10.7		5.6		6.8	
s 11	Corn and oats,	10.5		4.1		3.4	
s 16	Corn and oats,	10.3		6.1		4.1	
s 41	Corn and oats,	11.3		3.9		4.7	
s 34	Corn and oats,	11.1		4.9		7.4	
s 12	[1]Chop, No. 1,	11.6		5.2		5.5	
s 17	[3]Mixed feed, "Badger,"	16.8		7.1		9.0	
s 39	[1]Feed, No. 2, bran, meal and middlings,	15.3		5.1		7.5	
s 36	Middlings, winter wheat,	19.8		6.1		4.6	
s 37	Flour, for feed,	13.6		1.6		0.6	
123	American poultry food,	13.1	13.65	6.8	3.96	4.1	25.00
171	American poultry food,	13.3	13.65	7.2	3.96	4.8	25.00
162	H. O. Co.'s poultry feed,	17.4	17.0	5.4	5.5	5.1	30.00
208	H. O. Co.'s poultry feed,	17.4	17.0	5.8	5.5	5.0	30.00
119	Bowker's animal meal,	46.5	30.0	10.1	5.0		45.00
166	Bowker's animal meal,	39.1	30.0	10.3	5.0		60.00
175	Ground meat and bone,	44.4	45-51	17.7	15-22		30.00
188	Evap. bone and meat meal,	39.8	41.40	16.5	19.75		30.00
s 33	Champion poultry food,	23.8	40.0	9.6	8.0		

1 Not licensed in this State in 1900.
2 Sample taken at mill
3 Subject to license as marked.
4 Bought of Wilson & Eaton, Amenia, N. Y., for Royal Mixed Feed.
5 If licensed no evidence shown

TABLE IV.—SAMPLES OF FEEDING STUFFS

Collection No.	Name and address of manufacturer or jobber.	Sampled at
245	American Cotton Oil Co., Little Rock, Ark.,	Homer, Newton & Co.,
254	American Cotton Oil Co., Little Rock, Ark.,	Marathon, Marathon Roller Mills,
301	American Cotton Oil Co., New York,	Binghamton, Geo. Q. Moon & Co.,
360	American Cotton Oil Co., Helena, Ark.,	Oswego, Geo. H. Hunt,
346	Chapin & Co., St. Louis, Mo.,	Oxford, Byron Gray,
286	Chattanooga Cotton Oil Co., Chattanooga, Tenn.,	Owego, Geo. Nichols,
260	Empire Grain & Elevator Co., Binghampton,	Whitney's Point, A. F. Sanders,
326	Hunter Bros., St. Louis, Mo.,	Oneonta, Ford & Rowe,
352	Independent Cottonseed Oil Co., Memphis, Tenn.,	Norwich, H. O. Hale,
361	Independent Cottonseed Oil Co., Memphis, Tenn.,	Oswego, Geo. H. Hunt,
320	Oneonta Milling Co., Oneonta,	Sidney, Roseboom & Ingraham,
338	J. G. Fall & Co., Memphis, Tenn.,	Oneonta, Oneonta Milling Co.,
339	Booker & Gentry, Memphis, Tenn.,	Oneonta, Oneonta Milling Co.,
222	American Linseed Co., New York,	Auburn, W. L. Noyes,
292	American Linseed Co., New York,	Binghamton, Binghamton Produce Co.,
300	American Linseed Co., New York,	Binghamton, Geo. Q. Moon & Co.,
363	American Linseed Co., New York,	Phœnix, A. C. Parker,
273	Dayton Milling Co., Towanda, Pa.,	Waverly, John C. Shear,
244	Empire Grain & Elevator Co., Binghamton,	Homer, Newton & Co.,
267	Hauenstein & Co., Buffalo,	Elmira, A. F. Rohmer,
284	Mann Bros., & Co., Buffalo,	Waverly, D. V. Personius & Son,
325	Midland Linseed Oil Co., Minneapolis, Minn.,	Oneonta, Ford & Rowe,
336	National Linseed Co., New York,	Oneonta, Oneonta Milling Co.,
319	Oneonta Milling Co., Oneonta,	Sidney, Roseboom & Ingraham,
373	Union Linseed Co., Troy,	Penn Yan, John Conklin & Son,
231	Glucose Sugar Refining Co., Chicago, Ill.,	Cortland, S. N. Holden & Co.,
304	Glucose Sugar Refining Co., Chicago, Ill.,	Binghamton, Empire Grain & Elevator Co.,
239	Glucose Sugar Refining Co., Chicago, Ill.,	Cortland, Brayton Bros.,
249	Glucose Sugar Refining Co., Chicago, Ill.,	Marathon, J. H. Sieber & Son,
277	Glucose Sugar Refining Co., Chicago, Ill.,	Waverly, John C. Shear,
283	Glucose Sugar Refining Co., Chicago, Ill.,	Waverly, D. V. Personius & Son,
318	Glucose Sugar Refining Co., Chicago, Ill.,	Walton, Smith & St. John,
357	Glucose Sugar Refining Co., Chicago, Ill.,	Norwich, Robert D. Eaton,
258	Glucose Sugar Refining Co., Chicago, Ill.,	Whitney's Point, Henry Braman,

Collected During the Spring of 1901.

Collection No.	Name of feed.	Protein.		Fat.		Crude fiber found.	Price per ton.
		Found.	Guaranteed.	Found.	Guaranteed.		
		Per ct.	Per ct.	Per ct	Per ct.	Per ct.	
245	Cottonseed meal, prime,	42.1	43.0	9.0	9.0		$30.00
254	Cottonseed meal, prime,	43.2	43.0	10.2	9.0		31.00
301	Cottonseed meal,	46.6	43.0	9.5	9.0		26.50
360	Cottonseed meal, prime,	45.1	43.0	9.9	9.0		27.00
346	Cottonseed meal,	45.0	43.0	9.4	9.0		26.00
286	[1] Cottonseed meal,	44.0	——	9.8	——		26.00
260	[1] Cottonseed meal, "Lily" brand,	44.6	43.0	8.5	9.0		27.00
326	Cottonseed meal,	43.0	43.0	9.6	9.0		24.50
352	[1] Cottonseed meal, "Sunny South,"	24.1	25.0	6.2	6–7	20.0	26.00
361	Cottonseed meal, prime,	45.5	42–45	10.7	8–12		27.00
320	[4] Cottonseed meal,	44.4	43.0	8.2	9.0		27.00
338	[1] Cottonseed meal,	45.6	41–43	9.3	9–10		25.00
339	[1] Cottonseed meal,	43.3	43.0	9.1	9.0		25.00
222	Oil meal, O. P.,	36.1	32–36	8.8	5–7		
292	Oil meal, O. P.,	32.3	32–36	7.7	5–7		28.75
300	Oil meal, O. P.,	34.0	32–36	7.4	5–7		30.00
363	Oil meal, O. P.,	36.6	32–36	8.1	5–7		
273	[1] Oil meal, O. P.,	38.7	——	2.6	——		36.00
244	[4] Oil meal, O. P.,	31.3	——	7.4	——		33.00
267	Oil meal, O. P.,	37.1	40.96	7.4	8.65		40.00
284	Oil meal, O. P.,	35.4	35.15	7.1	7.05		40.00
325	Oil meal, O. P.,	29.7	32–38	8.0	5.75–9		27.50
336	[1] Oil meal, O. P.,	30.3	——	6.8	——		28.00
319	[4] Oil meal, O. P.,	37.8	38–40	2.2	1–3		30.00
373	Oil meal, Cow brand,	35.4	22.09	7.5	6.32		
231	Gluten meal, Chicago,	39.1	38.0	3.0	3.2		25.00
304	Gluten meal, Chicago,	36.8	38.0	4.8	3.2		24.00
239	Gluten feed, Buffalo,	25.9	28.5	2.7	3.3		21.00
249	Gluten feed, Buffalo,	27.1	28.5	3.9	3.3		20.00
277	Gluten feed, Buffalo,	27.4	28.5	3.5	3.3		21.00
283	Gluten feed, Buffalo,	26.9	28.5	4.2	3.3		21.00
318	Gluten feed, Buffalo,	27.4	28.5	4.2	3.3		20.50
357	Gluten feed, Buffalo,	24.9	28.5	3.8	3.3		21.00
258	Gluten feed, Marshallton,	28.6	28.5	3.7	3.3		20.00

TABLE IV.

Collection No.	Name and address of manufacturer or jobber.	Sampled at
308	Glucose Sugar Refining Co., Chicago, Ill.,	Deposit, Hinman Bros.,
310	Glucose Sugar Refining Co., Chicago, Ill.,	Deposit, Deposit Milling Co.,
235	Glucose Sugar Refining Co., Chicago, Ill.,	Cortland, S. N. Holden & Co.,
288	Glucose Sugar Refining Co., Chicago, Ill.,	Owego, Geo. Nichols,
322	Oneonta Milling Co., Oneonta.	Sidney, Roseboom & Ingraham,
228	U. S. Sugar Refining Co., Chicago, Ill.,	Cortland, I. V. Johnson,
242	U. S. Sugar Refining Co., Chicago, Ill.,	Homer, W. H. Darby,
252	U. S. Sugar Refining Co., Chicago, Ill.,	Marathon, Marathon Roller Mills,
323	U. S. Sugar Refining Co., Chicago, Ill.,	Oneonta, Ford & Rowe,
359	U. S. Sugar Refining Co., Chicago, Ill.,	Oswego, Geo. H. Hunt,
240	Glucose Sugar Refining Co., Chicago, Ill.,	Cortland, Brayton Bros.,
340	Glucose Sugar Refining Co., Chicago, Ill.,	Oneonta, Oneonta Milling Co.,
219	Banner Food Co., Auburn,	*
230	Barwell, J. W., Waukegan, Ill.,	Cortland, I. V. Johnson,
264	Barwell, J. W., Waukegan, Ill.,	Elmira, D. Bevier,
276	Barwell, J. W., Waukegan, Ill.,	Waverly, John C. Shear,
366	Nester, S. K., Geneva,	*
226	American Cereal Co., Chicago, Ill.,	Cortland, I. V. Johnson,
256	American Cereal Co., Chicago, Ill.,	Whitney's Point, Homer Smith,
289	American Cereal Co., Chicago, Ill.,	Owego, Geo. Nichols,
298	American Cereal Co., Chicago, Ill.,	Binghamton, B. Baker,
370	American Cereal Co., Chicago, Ill.,	Geneva, Geneva Coal Co.,
324	Blue River Milling Co., Edinburg, Ind.,	Oneonta, Ford & Rowe,
241	Fish & Co., New York,	Homer, W. H. Darby,
341	Hunter Bros., St. Louis, Mo.,	Oneonta, Oneonta Milling Co.,
327	Kehlor Bros., St. Louis, Mo.,	Oneonta, Morris Bros.,
367	Kehlor Bros., St. Louis, Mo.,	Geneva, J. J. Holman,
333	National Milling Co., Toledo, O.,	Oneonta, Morris Bros.,
355	National Milling Co., Toledo, O.,	Norwich, Robert D. Eaton,
s 31	Strait, C. W., Homer,	*
232	H. O. Co., Buffalo,	Cortland, S. N. Holden & Co.,
315	H. O. Co., Buffalo,	Walton, Smith & St. John,
330	H. O. Co., Buffalo,	Oneonta, Morris Bros.,
354	H. O. Co., Buffalo,	Norwich, H. O. Hale,
293	H. O. Co., Buffalo,	Binghamton, Binghamton Produce Co.,
316	H. O. Co., Buffalo,	Walton, Smith & St. John,
329	H. O. Co., Buffalo,	Oneonta, Morris Bros.,
343	Oneonta Milling Co., Oneonta,	*
251	American Cereal Co., Chicago, Ill.,	Marathon, J. H. Sieber & Son,
274	American Cereal Co., Chicago, Ill.,	Waverly, John C. Shear,
306	American Cereal Co., Chicago, Ill.,	Binghamton, Empire Grain & Elevator Co.,
349	American Cereal Co., Chicago, Ill.,	Oxford, Byron Gray,

—*Continued.*

Collection No.	Name of feed.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed	Crude fiber found.	Price per ton.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
308	Gluten feed, Marshallton,	30.1	28.5	4.0	3.3		$21.00
310	Gluten feed, Marshallton,	28.8	28.5	4.9	3.3		21.00
235	Gluten feed, Rockford diamond,	25.7	28.5	4.7	3.3		20.00
288	Gluten feed, Rockford diamond,	27.2	28.5	4.9	3.3		20.00
322	[4] Gluten feed,	13.6	——	3.8	——		20.00
228	Gluten feed, Waukegan,	22.4	27.38	4.5	3.39		20.00
242	Gluten feed, Waukegan,	27.0	27.38	4.2	3.39		20.00
252	Gluten feed, Waukegan,	27.1	27.38	4.3	3.39		20.00
323	Gluten feed, Waukegan,	27.3	27.38	5.1	3.39		20.40
359	Gluten feed, Waukegan,	26.9	27.38	6.2	3.39		22.00
240	Germ oil meal,	23.9	25.5	8.6	10.5		28.00
340	Germ oil meal,	21.1	25.5	12.0	10.5		22.00
219	Banner stock food,	26.9	25.0	6.6	5.0	12.2	160.00
230	Blatchford's calf meal,	25.1	26.0	5.0	5.0		70.00
264	Blatchford's calf meal,	24.4	26.0	5.4	5.0		70.00
276	Blatchford's calf meal,	25.8	26.0	5.5	5.0		70.00
366	Malt sprouts,	26.6	25.0	4.1	2.0		15.00
226	Buckeye wheat feed,	17.3	16.21	4.9	4.48		20.00
256	Buckeye wheat feed,	16.7	16.21	5.2	4.48		19.75
289	Buckeye wheat feed,	18.1	16.21	4.9	4.48		20.00
298	Buckeye wheat feed,	18.3	16.21	4.9	4.48		20.00
370	Buckeye wheat feed,	16.7	16.21	5.1	4.48		
324	[3] Mixed feed,	17.3	——	5.4	——	7.8	
241	[3] Mixed feed, "Rex,"	17.5	——	4.9	——	8.2	
341	[3] Mixed feed, "Excelsior,"	17.3	——	5.0	——	8.2	
327	[3] Mixed feed,	17.3	——	5.3	——	8.6	21.00
367	[3] Mixed feed,	16.7	——	5.1	——	8.2	21.50
333	[3] Delaware feed,	17.0	——	4.9	——	7.4	21.00
355	Delaware feed,	16.9	——	5.4	——	7.6	20.00
s 31	Bran and middlings,	15.6	——	4.9	——	7.6	
232	H. O. Co.'s dairy feed,	19.4	18.0	4.9	4.5	13.0	20.00
315	H. O. Co.'s dairy feed,	18.7	18.0	4.7	4.5	11.9	23.00
330	H. O. Co.'s dairy feed,	18.8	18.0	4.7	4.5	12.0	21.50
354	H. O. Co.'s dairy feed,	18.1	18.0	4.8	4.5	11.8	21.00
293	H. O. Co.'s horse feed,	12.3	12.0	4.2	4.5	9.6	22.00
316	H. O. Co.'s horse feed,	13.2	12.0	4.1	4.5	9.1	22.00
329	H. O. Co.'s horse feed,	13.2	12.0	4.0	4.5	9.6	21.50
343	Monarch horse feed,	13.2	13.0	5.3	5.75	8.5	23.00
251	Quaker dairy feed,	14.1	12.03	3.6	2.50	15.5	18.00
274	Quaker dairy feed,	14.4	12.03	4.0	2.50	15.0	18.00
306	Quaker dairy feed,	14.7	12.03	3.9	2.50	15.9	17.00
349	Quaker dairy feed,	13.4	12.03	3.6	2.50	15.2	18.00

TABLE IV.

Collection No.	Name and address of manufacturer or jobber.	Sampled at
369	American Cereal Co., Chicago, Ill.,	Geneva, Geneva Coal Co.,
237	American Cereal Co., Chicago, Ill.,	Cortland, S. N. Holden & Co.,
353	American Cereal Co., Chicago, Ill.,	Norwich, H. O. Hale.
368	American Cereal Co., Chicago, Ill.,	Geneva, Geneva Coal Co.,
248	American Malting Co., Detroit, Mich.,	Marathon, J. H. Sieber & Son,
234	Chapin & Co., St. Louis, Mo.,	Cortland, S. N. Holden & Co.,
347	Chapin & Co., St. Louis, Mo.,	Oxford, Byron Gray,
225	Clapp, Arthur Jerome, New York,	Cortland, C. O. Smith,
243	Cox, C. M., & Co., Geneva,	Homer, Newton & Co.,
238	Empire Grain & Elevator Co., Binghampton,	Cortland, Brayton Bros.
255	Empire Grain & Elevator Co., Binghampton,	Whitney's Point, Homer Smith,
259	Empire Grain & Elevator Co., Binghampton,	Whitney's Point, Henry Braman,
302	Hudnut Co., Terre Haute, Ind.,	Binghamton, Empire Grain & Elevator Co.,
328	Hudnut Co., Terre Haute, Ind.,	Oneonta, Morris Bros.,
247	Indianapolis Hominy Mills, Indianapolis, Ind.,	Homer, Paul Billings & Co.,
335	Miami Maize Co., Toledo, O.,	Oneonta, Oneonta Milling Co.,
365	Patent Cereals Co., Geneva,	[a]
356	Rodebaugh, J. H., Buffalo,	Norwich, Robert D. Eaton,
299	Seymore & Co., Buffalo,	Binghamton, Geo. Q. Moon & Co.,
309	Shellabarger Mill & Elevator Co., Decatur, Ill.,	Deposit, Deposit Milling Co.,
321	Shellabarger Mill & Elevator Co., Decatur, Ill.,	Sidney, Roseboom & Ingraham,
305	Suffern Hunt & Co., Decatur, Ill.,	Binghamton, Empire Grain & Elevator Co.,
236	Glucose Sugar Refining Co., Chicago, Ill.,	Cortland, S. N. Holden & Co.,
250	Glucose Sugar Refining Co., Chicago, Ill.,	Marathon, J. H. Sieber & Son,
253	Glucose Sugar Refining Co., Chicago, Ill.,	Marathon, Marathon Roller Mills,
280	Glucose Sugar Refining Co., Chicago, Ill.,	Waverly, D. V. Personius & Son,
334	Glucose Sugar Refining Co., Chicago, Ill.,	Oneonta, Oneonta Milling Co.,
358	Glucose Sugar Refining Co., Chicago, Ill.,	Norwich, Robert D. Eaton,
282	Parsonius, D. V., & Son, Waverly,	[a]
371	Adikes, J. & T., Jamaica,	[a]
337	Akron Cereal Co., Akron, O.,	Oneonta, Oneonta Milling Co.,
221	American Cereal Co., Chicago, Ill.,	Auburn, W. L. Noyes,
233	American Cereal Co., Chicago, Ill.,	Cortland, S. N. Holden & Co.,
257	American Cereal Co., Chicago, Ill.,	Whitney's Point, Homer Smith,

—Continued.

Collection No.	Name of feed.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude fibre found.	Price per ton.
		Per ct.	*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*	
369	Quaker dairy feed,	12.8	12.03	4.1	2.50	16.5	$18.00
237	Schumacher's stock feed,	11.5	10.79	5.4	3.28	11.5	20.00
353	Schumacher's stock feed,	11.6	10.79	5.0	3.28	11.8	20.00
368	Schumacher's stock feed,	11.2	10.79	4.2	3.28	11.1	20.00
248	Hominy feed,	10.4	9.89	8.6	7.06		18.00
234	Hominy feed, green diamond,	10.1	11.0	8.2	8.0		19.00
347	Hominy feed, green diamond,	10.5	11.0	8.5	8.0		18.00
225	[1]Hominy meal, pop corn,	11.7	——	10.4	——	4.6	19.00
243	[4]Hominy meal,	10.4	——	8.5	——		18.50
238	[4]Hominy meal,	11.7	——	9.7	——		20.00
255	[4]Hominy meal,	10.9	——	8.0	——		20.00
259	[4]Hominy meal,	10.3	——	6.4	——		19.00
302	Hominy feed,	11.3	12.85	7.7	8.52		18.75
328	Hominy feed,	10.2	12.85	7.7	8.52		18.50
247	Hominy feed,	12.4	11.10	10.0	10.47		19.00
335	Hominy feed,	10.5	10.93	7.9	7.05		18.00
365	Hominy feed,	10.9	11.46	10.0	9.30		17.00
356	[4]Hominy feed,	10.8	——	9.7	——		18.50
299	[4]Hominy feed,	10.7	——	7.9	——		20.00
309	Hominy feed,	11.1	11.14	9.6	9.02		18.00
321	Hominy feed,	13.4	11.14	9.3	9.02		18.00
305	Hominy feed,	11.1	11.02	9.1	7.70		18.75
236	Sugar corn feed,	14.6	14.0	4.7	2.5	11.1	18.00
250	Fancy corn bran,	12.4	14.0	4.3	2.5	11.6	18.00
253	Fancy corn bran,	11.1	14.0	4.3	2.5	10.7	17.00
280	Sugar corn feed,	13.3	14.0	4.6	2.5		
334	Sugar corn feed,	14.0	14.0	3.9	2.5		18.00
358	Fancy corn bran,	12.8	14.0	5.0	2.5		17.50
282	[4]Sugar corn feed,	11.9	——	6.6	——		17.00
371	Ground feed,	9.1	8.75	3.2	3.00	6.7	19.60
337	Royal oat feed,	6.3	8.25	2.7	4.14	25.4	16.00
221	Victor corn and oat feed,	8.3	8.23	3.6	3.00	9.3	18.00
233	Victor corn and oat feed,	8.8	8.23	3.1	3.00	11.4	17.00
257	Victor corn and oat feed,	9.6	8.23	4.7	3.00	7.6	19.00

TABLE IV.

Collection No.	Name and address of manufacturer or jobber.	Sampled at
294	American Cereal Co., Chicago, Ill.,	Binghamton, Binghamton Produce Co.,
307	American Cereal Co., Chicago, Ill.,	Binghamton, Geo. Q. Moon & Co.,
362	American Cereal Co., Chicago, Ill.,	Oswego, Geo. H. Hunt,
270	American Cereal Co., Chicago, Ill.,	Corning, S. T. Hayt,
281	American Cereal Co., Chicago, Ill.,	Waverly, D. V. Personius & Son,
246	Billings, Paul, & Co., Tunkhannock, Pa.,	Homer, Paul Billings & Co.,
261	Cerealine Mfg. Co., Indianapolis, Ind.,	Whitney's Point, A. F. Sanders,
350	Cerealine Mfg. Co., Indianapolis, Ind.,	Oxford, French & Mead,
372	Cerealine Mfg. Co., Indianapolis, Ind.,	Goshen, H. B. Knight & Co.,
348	Chester Mills, New York,	Oxford, Byron Gray,
272	Dayton Milling Co., Towanda, Pa.,	Waverly, John C. Shear,
s 28	Dayton Milling Co., Towanda, Pa.,	Waverly, John C. Shear,
220	Diamond Mills, Buffalo,	Auburn, W. L. Noyes,
266	Diamond Mills, Buffalo,	Elmira, John Livens,
271	Diamond Mills, Buffalo,	Corning, C. F. Brown,
312	Diamond Mills, Buffalo,	Hancock, E. E. Hackett & Co.,
269	Hayt, S. T., Corning,	[3]
291	Heath, H. R., & Sons, Fort Dodge, Ia.,	Binghamton, A. J. Smith & Son,
303	Heath, H. R., & Sons, Fort Dodge, Ia.,	Binghamton, Empire Grain
364	Heath, H. R., & Sons, Fort Dodge, Ia.,	& Elevator Co.,
265	Husted Milling & Elevator Co., Buffalo,	Phœnix, A. C. Parker,
314	Keery, Thomas (Cadosia Mills), Hancock,	Elmira, F. S. Knapp,
268	Kentucky Milling Co., Henderson, Ky.,	[3]
351	Kentucky Milling Co., Henderson, Ky.,	Elmira, H. F. Rohmer,
		Oxford, French & Mead,
290	Muscatine Oat Meal Co., Muscatine, Ia.,	Owego, Gilbert Truman & Son,
342	Oneonta Milling Co., Oneonta,	[3]
344	Oneonta Milling Co., Oneonta,	[3]
279	Personius, D. V., & Sons, Waverly,	[3]
311	Rathbun-Sawyer Co., Oneida,	Hancock, E. E. Hackett & Co.,
317	Rathbun-Sawyer Co., Oneida,	Walton, Smith & St. John,
s 27	American Cereal Co , Chicago, Ill.,	Oswego, Geo. H. Hunt,
s 8	Atlas Mills, Phœnix,	[2]
s 29	Barnum, S. D., Waverly,	[2]
s 3	Cadosia Mills, Hancock,	[3]
s 4	Cedar Falls Milling Co., Cedar Falls, Ia.;	Oswego, James Dunlap,
s 30	Darby, W. H., Homer,	[3]
s 26	Deposit Milling Co., Deposit,	[3]
s 6	Eaton, R. D., Norwich,	[3]
s 9	Fernbaugh Mills, Dresden,	Geneva, L. C. Davison,
s 7	French & Mead, Oxford,	[3]
s 1	Husted Milling & Elevator Co., Buffalo,	Norwich, H. O. Hale,
s 5	Pierce & Pendergast, Phœnix,	[3]
s 25	Barnum, S. D., Waverly,	[3]

—Continued.

Collection No.	Name of feed.	Protein. Found.	Protein. Guaranteed	Fat Found.	Fat Guaranteed.	Crude fiber found.	Price per ton.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
294	Victor corn and oat feed,	9.1	8.23	4.2	3.00	7.3	$19.00
307	Victor corn and oat feed,	7.8	8.23	3.1	3.00	11.8	
362	Victor corn and oat feed,	9.0	8.23	5.5	3.00	9.4	18.00
270	Vim oat feed,	7.4	6.30	3.0	2.58	22.7	15.00
281	Vim oat feed,	4.6	6.30	1.7	2.58	28.9	
246	[1]Oat feed,	1.7	——	1.4	——	30.7	16.00
261	Cerealine feed, No. 2,	11.4	10.82	7.8	8.03	2.2	19.00
350	Cerealine feed, No. 2,	11.4	10.82	7.8	8.03	2.1	18.00
372	Cerealine germ oil cake,	17.4	15.63	12.6	8.00		24.00
348	[1]Chester stock food,	6.9	11.5	2.7	4.2	11.5	19.00
272	[1]Chop, No. 2,	9.4	——	4.0	——	4.4	18.00
s28	Chop, No. 2,	9.6	——	4.3	——	5.1	21.00
220	Diamond C. and O. feed,	6.6	9.44	3.2	4.78	15.2	18.00
266	Diamond C. and O. feed,	6.8	9.44	3.4	4.78	12.1	18.00
271	Diamond C. and O. feed,	6.8	9.44	2.8	4.78	13.5	18.00
312	Diamond C. and O. feed,	7.9	9.44	3.7	4.78	12.5	18.00
269	Corn and oats,	9.6	10.43	4.2	4.00	8.5	18.00
291	Yankee corn and oat feed,	6.3	8.96	2.3	4.33	18.7	
303	Yankee corn and oat feed,	6.8	8.96	2.4	4.33	17.3	16.50
364	Yankee corn and oat feed,	7.5	8.96	3.2	4.33	15.1	18.00
265	Monarch chop feed,	7.9	10.40	3.4	3.27	8.3	19.00
314	Crescent corn and oat feed,	8.5	8.34	3.9	2.60	11.8	18.50
268	Jersey mixed feed,	13.4	11.56	3.8	3.65	13.4	20.00
351	Jersey mixed feed,	11.8	11.56	3.9	3.65	13.2	20.00
290	Friends concentrated dairy feed,	7.7	10.9	3.2	3.7	23.5	15.50
342	Arrow corn and oat feed,	9.0	9.00	4.5	3.75	5.4	19.00
344	Corn and oat provender,	9.3	8.75	4.7	3.50	10.7	18.00
279	Corn and oat feed,	8.2	7.94	2.6	4.18	7.1	20.00
311	Oneida chop feed,	9.4	10.5 to 13.5	5.1	3.0 to 4.5	8.2	18.00
317	[3]Oneida buckwheat feed,	19.7	——	5.7	——	24.4	14.00
s 27	Ground oats (calf meal)	16.9		8.6		2.0	
s 8	Corn and oats,	11.4		3.8		7.5	
s 29	Corn and oats,	9.5		1.4		3.3	
s 3	Corn and oats,	9.8		2.2		3.1	
s 4	Corn and oats,	11.6		5.0		6.4	
s 30	Corn and oats,	10.0		1.7		5.1	
s 26	Corn and oats,	11.1		1.8		5.9	
s 6	Corn and oats,	10.6		3.6		4.7	
s 9	Corn and oats,	11.2		4.5		6.1	
s 7	Corn and oats,	10.4		4.5		4.6	
s 1	Corn and oats,	9.9		3.1		4.1	
s 5	Corn and oats,	10.6		2.3		7.2	
s 25	Buckwheat, corn and oats,	9.4		1.5		5.4	

TABLE IV.

Collection No.	Name and address of manufacturer or jobber.	Sampled at
s 32	Berger-Anderson Co., Milwaukee, Wis.,	Cortland, S. N. Holden & Co.,
s 2	Oneonta Milling Co., Oneonta,	Sidney, Roseboom & Ingraham.
227	American Cereal Co., Chicago, Ill.,	Cortland, I. V. Johnson,
278	American Cereal Co., Chicago, Ill.,	Waverly, John C. Shear,
287	American Cereal Co., Chicago, Ill.,	Owego, Geo. Nichols,
332	American Cereal Co., Chicago, Ill.,	Oneonta, Morris Bros.,
313	H. O. Co., Buffalo,	Hancock, Wm. A. Hall,
331	H. O. Co., Buffalo,	Oneonta, Morris Bros.,
295	Mapes, O. W., Middletown,	Binghamton, Binghamton Produce Co.,
275	Bowker Fertilizer Co., Boston, Mass.,	Waverly, John C. Shear,
374	Bowker Fertilizer Co., Boston, Mass.,	West Winfield, H. W. Berry,
375	Bowker Fertilizer Co., Boston, Mass.,	Sprout Brook, A. E. Ostrom,
224	Finn's, H., Sons, Syracuse,	•
223	Finn's, H., Sons, Syracuse,	Auburn, W. L. Noyes,
285	Flour City Plant Food Co., Rochester,	Owego, Geo. Nichols,
262	Harding, Geo. L., Binghamton,	Whitney's Point, A. F. Sanders,
296	Harding, Geo. L., Binghamton,	[a]
297	Harding, Geo. L., Binghamton,	[a]
263	Preston Fertilizer Co., Brooklyn,	Elmira, D. Bevier,
229	Romaine, DeWitt, Hackensack, N. J.,	Cortland, I. V. Johnson,

—*Concluded.*

Col-lection No.	Name of feed.	Protein. Found	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude fiber found.	Price per ton.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
s 32	Badger bran,	14.3		3.7		7.7	
s 2	Rye feed,	14.8		4.0		6.0	
227	American poultry food,	13.9	13.65	7.4	3.96	4.7	$25.00
278	American poultry food,	12.9	13.65	5.5	3.96		26.00
287	American poultry food,	12.8	13.65	7.1	3.96	4.3	25.00
332	American poultry food,	14.5	13.65	6.3	3.96	4.8	26.00
313	H. O. poultry feed,	17.4	17.0	5.7	5.5	4.9	30.00
331	H. O. poultry feed,	17.2	17.0	5.7	5.5	5.3	28.00
295	Mapes balanced ration for poultry,	12.9	14.0	4.1	4.5	3.7	30.00
275	Bowker's animal meal,	25.2	30.0	16.8	5.0		52.00
374	Bowker's animal meal,	39.4	30.0	8.9	5.0		
375	Bowker's animal meal,	33.9	30.0	21.8	5.0		
224	Ground beef cracklings,	42.2	50.68	19.4	20.66		30.00
223	Ground beef cracklings,	44.0	50.68	19.2	20.66		45.00
285	[1]Excelsior meat meal for poultry,	35.1		13.5			45.00
262	Fresh ground beef scraps,	44.4	42.0	18.4	38.0		50.00
296	Fresh ground beef scraps,	40.3	42.0	30.9	38.0		45.00
297	Meat meal for poultry,	66.2	49.0	19.5	19.0		40.00
263	[1]Champion meat meal for poultry,	41.4	40.0	11.5	8.0		50.00
229	Boiled beef and bone,	47.2	45.0	18.7	15.0		45.00

[1] Not licensed in this State.
[2] Sample taken at mill.
[3] Subject to license as marked.
[4] If licensed, no evidence shown.

COMMENTS.

It is gratifying to note that the unmixed, or what may perhaps properly be termed, the standard, feeding stuffs, such as cottonseed and linseed oil meals, the gluten meals and feeds, the brewer's residues and hominy feeds, are of uniformly good quality and are practically as good as the guarantees. The only important instance of inferior quality in these classes of goods is the case of Mayflower Linseed Meal manufactured by the Mayflower Mills, Fort Wayne, Ind. It is believed that this brand has been withdrawn from the market. It is clearly fraudulent in character, as the protein was only about half the proportion represented to be present.

The most numerous discrepancies between guarantees and actual composition occur with the mixed goods of which oat hulls are undoubtedly a component. These are the goods which in many instances bear such brand names as "chop feed," "corn and oat feed," "mixed feed," etc., which lead the purchaser to conclude that the mixtures are made up of corn and oats. They have the appearance of being corn and oats, because corn meal or hominy feed and oat hulls are present. The protein guaranteed is usually less than 10 per ct., often less than 9 per ct. and in some brands less than 8 per ct., but even these low percentages are not always maintained because of an evident overdose of the worthless oat hulls.

The prominence of oat hulls in some of these mixtures is seen in the large proportion of fibre which they carry. The only grain product which supplies fibre generously is oat hulls, and when a mixture containing a considerable proportion of corn meal or hominy feed shows 12 per ct. of fiber and upwards, it is safe to conclude that oat hulls have been introduced. The same is true often when the fiber is less than 12 per ct. Attention is invited to the percentages of fiber given in the preceding tables.

Many genuine mixtures of corn and oats are sold. These seem to be more abundant, that is, they constitute a larger propor-

tion of the "chop feeds" found in the market, than was the case when the Station first began to collect samples of this class of goods. The genuineness of these mixtures is seen in part in the low proportion of fiber which ranges between 3 per ct. and 7 per ct., and in part in their general appearance. The presence of ground oat hulls is made evident by a characteristic mechanical condition and negatively by the absence of the crushed oat grains. It would not be difficult for farmers to so educate their eyes as to easily detect inferior oat hull mixtures.

It is claimed, probably for good reason, that much of the corn meal sold in the State is mixed with hominy feed. While such a mixture is little, if any, inferior in feeding value to pure corn meal, the purchaser generally sustains financial injury, because if he wishes for hominy feed he can usually purchase it at a less price than that paid for the fraudulent corn meal. These corn meal and hominy mixtures are lighter in color than pure, yellow corn meal. Proof that this lighter color is not caused by grinding in white corn is difficult, because chemically and microsopically hominy feed is very similar to the maize grain of which it was once a part.

It is fair to conclude, also, that the by-products from the manufacture of starch are used to mix with corn meal whenever they cost less than the latter. This fact was made evident at a public hearing before a committee of the New York legislature at the time legislation concerning the sale of feeding stuffs was pending. Very recently a jobber in feeding stuffs located in New York has issued a circular to millers advising them how they can "make corn meal" "in order to meet competition" by mixing corn bran with corn meal in the proportion of one to five.

Without discussing here the question of the relative value of corn meal and the mixture, this practice, when not clearly understood, is a dishonest imposition upon the consumer, because if he wishes for corn bran in his ration he can buy it for less money than he can corn meal. Moreover, any miller who fraudulently descends to such unworthy means of sustaining his trade becomes legally liable to a fine.

One of the most frequent violations of the feeding stuff law is the failure of dealers to have in their possession the proper statement of the source and composition of licensed goods stored and sold in bulk. Licensed brands stored and sold in the manufacturer's sacks are usually properly marked. Because a brand is licensed the dealer handling it in bulk is not excused from the requirement of furnishing to the consumer the statement required by law. It should be entirely easy to secure such a statement from the manufacturer or jobber and there is no good reason for failing in this particular.

The sale of the offals from milling wheat has also required some attention. It is customary with many mills to run together all the offals, bran, middling, etc., and sell this mixture under the term "mixed feed."

The requirements of the feeding stuff law do not apply to bran and middlings from wheat, rye and buckwheat *when sold as such* and it has been necessary to rule that these cannot be sold in a mixed condition under the simple term "mixed feed" without complying with the provisions of the law, but must be labeled, if labeled at all, as pure bran and middlings.

For the information of dealers who desire to be law-abiding and avoid the responsibility of doing business illegally, the following list is given of goods either not licensed, or if licensed, without evidence of the same appearing as they were found in the hands of dealers.

The goods in this list should be avoided until they are placed on the market legally.

BRANDS TO BE AVOIDED BECAUSE OF NOT HAVING A LEGAL STANDING IN THIS STATE OR ELSE SOLD WITHOUT FULL COMPLIANCE WITH THE LAW.

Name.	Manufacturer or jobber.
* Cottonseed-meal,	Chattanooga Cotton Oil Co., Chattanooga, Tenn.
* Cottonseed-meal, Lily brand,	Empire Grain & Elevator Co., Binghamton, N. Y.
* Cottonseed-meal, Sunny South brand,	Independent Cotton Oil Co., Memphis, Tenn.
† Cottonseed-meal,	Oneonta Milling Co., Oneonta, N. Y.
* Cottonseed-meal,	J. G. Fall & Co., Memphis, Tenn.
* Cottonseed-meal,	Booker & Gentry, Memphis, Tenn.
* Mayflower linseed meal,	Mayflower Mills, Fort Wayne, Ind.
* Linseed meal, O. P.,	Dayton Milling Co., Towanda, Pa.
† Linseed meal, O. P.,	Empire Grain & Elevator Co., Binghamton, N. Y.
* Linseed meal, O. P.,	National Linseed Co., New York, N. Y.
† Linseed meal, O. P.,	Oneonta Milling Co., Oneonta, N. Y.
† Gluten feed,	Oneonta Milling Co., Oneonta, N. Y.
* Special gluten,	Oneonta Milling Co., Oneonta, N. Y.
* Daisy gluten feed,	Andrew Cullen Co., New York, N. Y.
* Popcorn hominy,	Arthur Jerome Clapp & Co., New York, N. Y., or John W. Metzler, Binghamton, N. Y.
* Hominy feed,	C. M. Cox & Co., Geneva, N. Y.
† Hominy feed,	Empire Grain & Elevator Co., Binghamton, N. Y.
† Hominy feed,	J. H. Rodebaugh, Buffalo, N. Y.
† Hominy feed,	Seymour & Co., Buffalo, N. Y.
† Sugar corn feed,	D. V. Personius & Son, Waverly, N. Y.
† Oat feed,	Paul Billings, New York, N. Y.
* Chester stock food,	Chester Mills, New York, N. Y.
* Chop No. 2,	Dayton Milling Co., Towanda, Pa.
* Excelsior meat meal for poultry,	Flower City Plant Food Co., Rochester, N. Y.
* Champion meat meal for poultry,	Preston Fertilizer Co., Brooklyn, N. Y.
‡ Rex mixed feed,	Fish & Co., New York, N. Y.
‡ Excelsior mixed feed,	Hunter Bros., St. Louis, Mo.
‡ Delaware feed,	National Milling Co., Toledo, O.

* Not licensed in 1901.
† If licensed, no evidence shown by dealer.
‡ Should be marked properly. Not legally sold under brand name used.

SUGGESTIONS TO DEALERS.

In this bulletin may be found a list of brands of feeding stuffs licensed for 1901. In the main the same brands will probably be licensed for 1902, doubtless with some additions. These include every variety of commercial cattle foods which farmers and stable keepers ever need to purchase outside of the entire cereal grains, which are not subject to the provisions of the law. The manufacturers or jobbers who have paid license fees and filed the required guarantees have made it possible for dealers to handle their goods safely and with certain assurances as to character and quality, and therefore they are the ones who are entitled to patronage.

Dealers should require that when goods are handled in packages the proper marks are affixed:

Name and address of manufacturer or jobber.
Name of brand.
Guaranteed percentage of protein.
Guaranteed percentage of fat.

If the goods are bought in bulk, then the manufacturer or jobber should be asked to furnish the same statement for display to customers. This is a simple matter, but it should be attended to in order to avoid any possible chance of action by the State and as a matter of justice to consumers.

SUGGESTIONS TO CONSUMERS.

There appears to be a growing tendency on the part of consumers to purchase proprietary brands of feeding stuffs that are mixtures of two or more by-products. Many of these mixtures are compounded for the purpose of providing a medium in which inferior waste products lose their identity by mixing them with materials of good and well recognized quality. For instance, an "oat feed" may contain hominy feed, oat hulls and sometimes enough of some material rich in protein, perhaps gluten meal, to bring the protein content of the mixture up to a desirable proportion. Such a mixture is worth commercially what the hominy feed and gluten meal would cost and no more. If 20 per ct. of oat hulls are present then the price of the mixtures should be 20 per ct. less than what a full ton of the hominy feed and gluten meal mixture would cost. Oat hull mixtures are not an imposition on the consumer, provided they are sold at a price proportional to the standard materials which the mixtures contain, otherwise they are bought at a loss. As a matter of fact, these mixtures are sold at about the prices which rule for feeding stuffs of standard grade.

A glance at the previous tables will show the following range of prices:

Proprietary mixed goods	$17.50 to $24.00	per ton.
Gluten meal	24.00 to 25.00	"
Gluten feeds	20.00 to 22.00	"
Hominy feeds	17.50 to 19.50	"
Sugar corn feed (corn bran mostly)	17.00 to 18.00	"
Malt sprouts	15.00	
Mixed wheat offals	20.00 or less.	

These figures show conclusively that the proprietary mixed goods containing 20 per ct. and upward of oat hulls are bought at a loss of generally not less than $5 per ton and doubtless often more. If farmers foolishly think that it is desirable to have in the grain mixture some fibrous material like oat hulls, let them hire someone to grind up their straw stacks or the mows of poor hay and mix the good grain with these. It is pitiful to see farmers of limited means paying grain prices for an ingredient in certain commercial cattle foods which is worth no more than the poorest coarse fodders around the barn. Such costly business management seems to be the fruit of either wilful ignorance or a lazy indifference.

The manufacturer who uses oat hulls in such a way as to deceive his customers is simply dishonest.

One of the most glaring impositions discovered is the case of sample 246, representing an "oat feed" found on sale at Homer. The oat feed (?) contained only 1.7 per ct. of protein and over 30 per ct. of fibre. It was nothing but oat hulls. The selling price was $15 per ton! Comment is unnecessary.

The wise course for farmers to pursue is to purchase either standard by-product feeding stuffs or the entire grains, such as corn and oats, whole or ground. At $1 per hundred for corn meal and 40 cents per bushel for oats, a mixture of equal parts by weight of these two grains can be secured at no greater price than what is asked for certain oat feeds. If hominy feed is used in place of the corn meal the cost would be lessened.

SO-CALLED "RED ALBUMEN" A FRAUD.*

W. H. JORDAN.

Poultry-feeders and farmers throughout western New York have been much excited during the past few weeks by the exploiting of "Red Albumen." Doubtless many of them have been victimized; for druggists report demands for this material almost unprecedented even in the sale of patent medicines, and so far as evidence collected by the Station goes each purchaser has been defrauded.

There are at least two preparations sold under the name red albumen, probably more; for the druggists in many places were evidently not supplied with the original material, but realized that the farmers were determined to be "gold-bricked" anyway and so met the demand by substituting compounds from their own stock. One of the preparations, that reaching the Station under the label of the United States Salyx Co., New Concord, Ohio, has practically no feeding value as it contains only $\frac{1}{10}$ of 1 per ct. of protein (albumen), the remainder being almost wholly oxide of iron (red paint) and sand. No phosphorus was found, nor was there any evidence of strychnine or the newly discovered (?) "alequet." Unless fraud has been worked upon the Salyx Co., this is the original "red albumen."

If so, instead of being worth 50 or 60 cents a pound, it is worth only from 1 to 2 cents a pound as "Mineral Red" or "Ground Iron Ore" used for paint.

Druggists, or others who have substituted some other product for the original "red albumen," have been less conscienceless toward the farmers; for they have sold them an albuminous compound, probably a by-product which contains 11 or 12 per ct. of nitrogen or about 72 per ct. protein. This sells for varying prices, depending upon the druggist's mood; but usually at the price fixed for the original article, 50 or 60 cents a pound. Animal meal, which supplies the best of albuminoid matter for poultry, contains more than half as much protein and sells at from 3 to 5 cents a pound.

---

* Reprint of a circular.

REPORT OF ANALYSES OF COMMERCIAL FERTILIZERS FOR THE SPRING AND FALL OF 1901.*

L. L. VAN SLYKE AND W. H. ANDREWS.

SUMMARY.

(1) **Samples collected.** During the year 1901, the Station collected 963 samples of commercial fertilizers, representing 465 different brands. Of these different brands 334 were complete fertilizers; of the others, 49 contained phosphoric acid and potash without nitrogen; 21 contained nitrogen and phosphoric acid without potash; 15 contained nitrogen only; 35 contained phosphoric acid alone; and 11 contained potash salts only.

(2) **Nitrogen.** The 334 brands of complete fertilizers contained nitrogen varying in amount from 0.36 to 8.10 per ct., and averaging 2.01 per ct. The average amount of nitrogen found by the Station analysis exceeded the average guaranteed amount by 0.12 per ct., the guaranteed average being 1.89 per ct., and the average found being 2.01 per ct.

In 250 brands of complete fertilizers, the amount of nitrogen found was equal to or above the guaranteed amount, the excess varying from 0.01 to 1.33 per ct., and averaging 0.22 per ct.

In 84 brands the nitrogen was below the guaranteed amount, the deficiency varying from 0.01 to 1.09 per ct., and averaging 0.18 per ct. In 78 cases, the deficiency was less than 0.5 per ct.

The amount of water-soluble nitrogen varied from 0 to 6.40 per ct. and averaged 0.87 per ct.

*A reprint of Bulletin No. 201.

(3) Available phosphoric acid. The 334 brands of complete fertilizers contained available phosphoric acid varying in amount from 1.01 to 13.46 per ct. and averaging 8.80 per ct. The average amount of available phosphoric acid found by the Station analysis exceeded the average guaranteed amount by 1.13 per ct., the guaranteed average being 7.67 per ct. and the average found being 8.80 per ct.

In 304 brands of complete fertilizers, the amount of available phosphoric acid found was equal to or above the amount guaranteed, the excess varying from 0.01 to 4.81 per ct. and averaging 1.26 per ct.

In 30 brands, the available phosphoric acid was below the guaranteed amount, the deficiency varying from 0.01 to 7.72 per ct. and averaging 0.74 per ct. In 24 cases the deficiency was below 0.5 per ct.

The amount of water-soluble phosphoric acid varied from 0 to 10.77 per ct. and averaged 5.04 per ct.

(4) Potash. The complete fertilizers contained potash varying in amount from 0.26 to 11.59 per ct., and averaging 4.47 per ct. The average amount of potash found by the Station analysis exceeded the average guaranteed amount by 0.34 per ct., the guaranteed average being 4.13 per ct., and the average found being 4.47 per ct.

In 259 brands of complete fertilizers, the amount of potash found was equal to or above the guaranteed amount, the excess varying from 0.01 to 4.75 per ct. and averaging 0.55 per ct.

In 75 brands, the potash was below the guaranteed amount, the deficiency varying from 0.01 to 4.71 per ct. and averaging 0.40 per ct. In 59 of these cases, the deficiency was less than 0.5 per ct.

In 70 cases among the 334 brands of complete fertilizers the potash was contained in the form of sulphate free from an excess of chlorides.

(5) The retail selling price of the complete fertilizers varied from $14 to $43 a ton and averaged $25.71. The retail cost of the separate ingredients unmixed averaged $19.81, or $5.90 less than the selling price.

INTRODUCTION.

NUMBER AND KINDS OF FERTILIZERS COLLECTED.

During the year 1901, the Station's collecting agents visited 179 towns between April 5 and October 16, obtaining 963 samples of commercial fertilizers. These samples represent 465 different brands, the product of 60 different manufacturers, each manufacturer being represented by from one to 202 brands.

The subjoined tabulated statement indicates the different classes included in the collection.

CLASSES OF FERTILIZERS COLLECTED.

Brands containing only nitrogen.	Brands containing only phosphoric acid.	Brands containing only potash.	Brands containing nitrogen and phosphoric acid without potash.	Brands containing phosphoric acid and potash without nitrogen.	Brands of complete fertilizers.
15	35	11	21	49	334

COMPOSITION OF FERTILIZERS COLLECTED.

The following tabulated statement shows the average composition of the complete fertilizers collected during the year, together with a comparison of the guaranteed composition and that found by analysis.

AVERAGE COMPOSITION OF COMPLETE FERTILIZERS COLLECTED.

	Per ct. guaranteed.			Per ct. found.			Average per ct. found above guarantee.
	Lowest.	Highest.	Average.	Lowest.	Highest	Average.	
Nitrogen	0.39	8.78	1.89	0.36	8.10	2.01	0.12
Available phosphoric acid	0.62	12.00	7.67	1.01	13.46	8.80	1.13
Insoluble phosphoric acid	——	——	——	0.00	6.10	2.32	——
Potash	0.75	12.00	4.13	0.26	11.59	4.47	0.34
Water-soluble nitrogen	——	——	——	0.00	6.40	0.87	——
Water-soluble phosphoric acid	——	——	——	0.00	10.77	5.04	——

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

The trade-values in the following schedule have been agreed upon by the Experiment Stations of Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Vermont, as a

result of study of the prices actually prevailing in the large markets of these states.

These trade-values represent, as nearly as can be estimated, the average prices at which, during the six months preceding March, the respective ingredients, *in the form of unmixed raw materials,* could be bought at retail for cash in our large markets. These prices also correspond (except in case of available phosphoric acid) to the average wholesale prices for the six months preceding March, plus about 20 per ct. in case of goods for which there are wholesale quotations.

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

	1901. Cts. per pound.
Nitrogen in ammonia salts	16½
Nitrogen in nitrates	14
Organic nitrogen in dry and fine-ground fish, meat and blood, and mixed fertilizers	16
Organic nitrogen in fine-ground bone and tankage	16
Organic nitrogen in coarse bone and tankage	12
Phosphoric acid, water-soluble	5
Phosphoric acid, citrate-soluble	4½
Phosphoric acid in fine-ground fish, bone and tankage	4
Phosphoric acid in coarse fish, bone and tankage	3
Phosphoric acid in mixed fertilizers, insoluble in ammonium citrate and water	2
Potash as high-grade sulphate, in forms free from muriates (chlorides), in ashes, etc.	5
Potash in muriate	4¼

COMPARISON OF SELLING PRICE AND COMMERCIAL VALUATION.

Giving to the different constituents the values assigned in the schedule for mixed fertilizers, 16 cents a pound for nitrogen, 5 cents a pound for water-soluble phosphoric acid 4½ cents a pound for citrate-soluble phosphoric acid, 2 cents a pound for insoluble phosphoric acid, and 4½ cents a pound for potash, we can calculate the commercial valuation, or the price at which the separate unmixed materials contained in one ton of fertilizer, having the composition indicated in the preceding table, could be purchased for cash at retail at the seaboard. Knowing the retail prices at which these goods were offered for sale, we can also readily estimate the difference between the actual sell-

ing price of the mixed goods and the retail cash cost of the unmixed materials; the difference covers the cost of mixing, freight, profits, etc. We present these data in the following table:

COMMERCIAL VALUATION AND SELLING PRICE OF COMPLETE FERTILIZERS.

Commercial valuation of complete fertilizers.	Selling price of one ton of complete fertilizers.			Average increased cost of mixed materials over unmixed materials for one ton
Average.	Lowest.	Highest.	Average.	
$19.81	$14	$43	$25.71	$5.90

COST OF ONE POUND OF PLANT-FOOD IN FERTILIZERS AS PURCHASED BY CONSUMERS.

In the table below we present figures showing the average cost to the purchaser of one pound of plant-food in different forms in mixed fertilizers.

AVERAGE COST OF ONE POUND OF PLANT-FOOD TO CONSUMERS IN MIXED FERTILIZERS.

Nitrogen	20.8 cents.
Phosphoric acid (available)	6.2 cents.
Potash	5.9 cents.

NEW FERTILIZER LAW.

The State legislature amended the fertilizer law in 1899 and attention is called to the principal changes that affect manufacturers and dealers.

(1) All fertilizers selling for *five* dollars or more per ton come under the law.

(2) Every manufacturer, importer, dealer or agent must pay a license fee amounting to *twenty* dollars a year for each separate brand or kind of fertilizer or fertilizing material.

(3) Statements of guarantee analysis, etc., are to be filed and license fees paid *during December* each year covering the goods to be sold during the year following.

(The analyses of samples collected, as given in the Bulletin, are not reprinted here; as they cease to have value before the report is distributed.—DIRECTOR).

REPORT OF ANALYSES OF PARIS GREEN AND OTHER INSECTICIDES IN 1901.* †

L. L. VAN SLYKE AND W. H. ANDREWS.

SUMMARY.

In accordance with the provisions of a law designed to protect purchasers of Paris Green, samples were secured during 1901 and the results are published in this Bulletin.

In the 40 samples of Paris Green examined, the arsenious oxide varied from 56.13 to 62.87 per ct. and averaged 58.10 per ct. The water-soluble arsenious oxide varied from 0.88 to 2.64 per ct. and averaged 1.28 per ct.

The copper oxide varied from 26.53 to 31.14 per ct. and averaged 29.88 per ct. The amount of arsenious oxide in combination with copper varied from 49.70 to 57.72 per ct. and averaged 55.98 per ct. The general result of the examination is to show a good quality of Paris Green in the market at the time the samples were taken.

There are given, in addition, analyses of English Bug Compound, Laurel Green, London Purple, and Paris-Green-Bordeaux-Mixture.

INTRODUCTION.

During the year 1901, there were collected for analysis forty samples of materials sold as Paris Green, and also two samples of Laurel Green and one sample each of English Bug Compound, London Purple, Paragrene and Paris-Green-Bordeaux Mixture. The forty samples of Paris green represent twenty different manufacturers, eight of whom were not represented in the samples examined by us in 1900.

*Printed by the authority and under the direction of the Commissioner of Agriculture.

†A reprint of Bulletin No. 204.

For a discussion of the chemistry of Paris green and for a statement of the methods of chemical analysis used, see Bulletin No. 190, p. 284.

Analyses of Samples of Paris Green in 1901.

No.	Manufacturer.	Total arsenious oxide. Per ct.	Water soluble arsenious oxide. Per ct.	Copper oxide. Per ct.	Arsenious oxide in combination with copper. Per ct.
61	Acme Color Works,	57.11	1.47	30.04	56.27
353	Acme Color Works,	57.66	1.47	30.04	56.27
57	Adler Color & Chemical Co.,	57.97	0.88	30.29	56.74
347	Adler Color & Chemical Co.,	56.93	2.64	30.10	56.38
59	A. B. Ansbacher & Co.,	57.11	0.88	30.23	56.63
301	A. B. Ansbacher & Co.,	57.84	1.47	30.48	57.10
302	A. B. Ansbacher & Co.,	56.93	1.10	30.35	56.85
60	James A. Blanchard,	57.42	1.53	28.54	53.46
303	James A. Blanchard,	57.11	1.53	29.22	54.73
305	James A. Blanchard,	57.35	1.53	29.66	55.56
362	George C. Buell & Co.,	57.72	1.65	29.41	55.09
65	Cawley, Clark & Co.,	57.42	1.35	31.23	57.42
63	Charles M. Childs & Co.,	57.85	1.23	30.08	56.35
357	Charles M. Childs & Co.,	58.76	0.98	30.41	56.97
355	Hampden Paint Co.,	58.82	1.10	30.16	56.50
66	Morris Herrmann & Co.,	61.40	1.78	27.47	51.46
310	Morris Herrmann & Co.,	62.87	2.21	26.78	50.17
340	Morris Herrmann & Co.,	62.69	1.53	26.53	49.70
69	Fred L. Lavanburg,	57.91	0.98	30.16	56.50
304	Fred L. Lavanburg,	57.91	0.98	30.48	57.10
307	Fred L. Lavanburg,	58.82	1.15	29.91	56.03
361	George E. Laverack,	58.03	1.23	29.85	55.91
56	Leggett & Bros.,	57.11	0.98	30.01	56.21
342	Leggett & Bros.,	56.13	1.23	29.54	55.34
343	Leggett & Bros.,	57.42	1.23	30.50	57.13
345	Leggett & Bros.,	57.42	0.98	30.41	56.97
68	N. Y. Enamel Paint Co.,	57.11	1.47	30.04	56.27
356	N. Y. Enamel Paint Co.,	58.09	1.72	30.23	56.63
358	N. Y. Enamel Paint Co.,	58.46	0.98	30.35	56.85
62	I. Pfeiffer,	57.35	1.10	30.04	56.27
350	I. Pfeiffer,	57.72	0.88	30.73	57.57
354	I. Pfeiffer,.	58.09	1.35	30.29	56.74
54	C. T. Reynolds & Co.,	60.72	1.40	28.35	53.11
306	Reynolds (Devoe, Reynolds & Co.),	57.29	1.10	30.54	57.21
311	Solomon & Schwartz,	57.60	0.88	30.85	57.60
308	Sondheim, Alsburg & Co.,	57.84	0.88	30.48	57.10
360	Stanley, Jordan & Co.,	58.58	1.40	29.60	55.45
341	John L. Thompson Sons,	57.60	0.88	30.29	56.74
67	Unknown,	57.72	0.98	31.14	57.72
351	Unknown,	58.09	0.98	30.16	56.50

Analyses of Samples of Other Insecticides.

359	English Bug Compound, English Compound Co.,	1.46	——	0.60	——
55	Laurel Green, Nichols Chemical Co.,	4.85	0	12.68	——
309	Laurel Green, Nichols Chemical Co.,	5.45	0	12.05	——
64	London Purple, Hemingway's London Purple Co.,	32.32	12.21	——	——
348	Paragrene, Fred L. Lavanburg,	41.73	0.88	21.06	——
344	Paris-Green-Bordeaux-Mixture, Leggett Bros.,	15.49	1.72	16.02	——

DISCUSSION OF RESULTS OF CHEMICAL ANALYSIS.

1. *Total arsenious oxide.*—In the 40 samples of materials sold as Paris green, examined by us, the amount or arsenic equivalent to arsenious oxide, varies from 56.13 to 62.87 per ct., and averaged 58.10 per ct. This average is over one per ct. higher than that found last year, and is about one-half per ct. below the equivalent of arsenious oxide contained in pure copper aceto-arsenite. So far as the total arsenic content is concerned, the amount found indicates a high quality of Paris green. The variation is about the same as last year and, excepting four samples, is within surprisingly narrow limits. Where the total amount of arsenic present in Paris green the only point to be considered, the quality would be regarded as very satisfactory, but we must consider at the same time the amount of water-soluble compounds of arsenic present in Paris green.

2. *Water-soluble compounds of arsenic.*—The presence of water-soluble arsenic in Paris green is seriously objectionable owing to the fact that soluble arsenic compounds injure foliage. Hilgard, of California, states that in the dry climate of California, Paris green injures foliage when it contains an equivalent of more than four per ct. of arsenious oxide in the form of soluble arsenic compounds. The water-soluble arsenic most commonly occurring in Paris green is in the form of arsenious oxide, commercally known as common white arsenic.

The method of analysis used by us in determining the amount of water-soluble arsenic compounds in Paris green should show the full amount of such compounds that would be found in actual field work where Paris green is mixed with water at the rate of one part by weight of Paris green to 1000 parts of water and the mixture used soon after preparation. By longer extraction with water, larger quantities of soluble arsenic compounds can be obtained; but for our purpose, it is desirable to approximate the amount likely to be found in actual field practice in the use of Paris green under the conditions commonly employed. It would, in our judgment, be proper to condemn for

use as an insecticide Paris green or other similar materials that yield more than $3\frac{1}{2}$ per ct. of water-soluble arsenic compounds expressed as arsenious oxide, when treated for 24 hours with distilled water at the rate of 1000 parts of water for one part of Paris green or arsenic-containing materials.

The water-soluble arsenious oxide varies in the 40 samples of Paris green examined from 0.88 to 2.64 per ct., and averages 1.28, which is far below the limit of harm prescribed for use as an insecticide and the limit fixed by law.

3. *Copper in Paris green determined as copper oxide.*—The amount of copper expressed as the equivalent of copper oxide, varies in the 40 samples of Paris green examined from 26.53 to 31.14 per ct. and averages 29.88 per ct., which is about the same as last year.

4. *Amount of arsenious oxide in combination with copper.*—The law relating to Paris green in this State was amended in 1901, so as to correct certain defects existing in the original law with reference to the definition of Paris green. The original law required that Paris green should contain the equivalent of 50 per ct. of arsenious oxide. This provision was needlessly low and was also open to the very serious objection that it permitted indefinite adulteration by common white arsenic. This defect has been corrected by requiring that Paris green shall contain arsenic *in combination with copper*, equivalent to not less than 50 per ct. of arsenious oxide. In ascertainig the amount of copper in combination with arsenic, it has been assumed that all the copper present was so combined, except when found in excess. While this assumption is not strictly accurate, it answers the purpose, especially when the precaution is taken to examine the Paris green for water-soluble forms of copper-compounds.

In the 40 samples of Paris green examined the amount of arsenious oxide in combination with copper varied from 49.70 to 57.72 per ct. and averaged 55.98 per ct., which is about 6 per ct. higher than the minimum required by law. Only one sample fell below the limit and this was only slightly below.

5. *General conclusion as to purity of Paris green in market.*— Our results indicate a satisfactory condition as to the arsenic content of Paris green found in the market during 1901, and the same can be said as to the amount of water-soluble compounds present in the samples examined.

AMENDMENT TO PARIS GREEN LAW.

In accordance with the suggestions made by us last year, that portion of the Paris Green Law which related to the definition of Paris green was changed. The essential portion of the amended law embodying this change is as follows:

"§ 112. Composition of Paris green or analogous products.— Paris green, or any product analogous to it, when sold, offered or exposed for sale as such, in this state, shall comply with the following requirements:

"First. It shall contain arsenic, in combination with copper, equivalent to not less than fifty percentum arsenious oxide.

"Second. It shall not contain arsenic in water-soluble forms equivalent to more than three and one-half per centum of arsenious oxide."

LIST OF PARTIES WHO RECEIVED PARIS GREEN CERTIFICATES IN 1901.

Acme Color Works, 5 Hanover street, New York.
Adler Color and Chemical Works, 100 William street, New York.
A. B. Ansbacher & Co., 4 Murray street, New York.
Louis Berger & Sons of America, Lim., 100 William street, New York.
Jas. A. Blanchard, 66 Maiden lane, New York.
Chas. M. Childs & Co., 225 Pearl street, New York.
O. W. Clark & Son, 59 Seneca street, Buffalo, N. Y.
F. W. Devoe and C. T. Reynolds Co., 101 Fulton street, New York.
Hampden Paint and Chemical Co., Springfield, Mass.
J. M. Huber, 275 Water street, New York.
Fred L. Lavanburg, 165 William street, New York.
Leggett & Bros., 301 Pearl street, New York.
John Lucas & Co., 89 Maiden lane, New York.
Morris, Hermann & Co., 255 Pearl street, New York.
I. Pfeiffer, 174 Fulton street, New York.

APPENDIX.

I. Periodicals Received by the Station.

II. Meteorological Records.

Appendix.

PERIODICALS RECEIVED BY THE STATION.

Acker und Gartenbau Zeitung................	Complimentary.
Agricultural Epitomist........................	"
Agricultural Gazette of New South Wales.....	"
Agricultural Journal of the Cape of Good Hope	"
Agricultural Students' Gazette...............	"
Albany Journal	Subscription.
Allegan Gazette.............................	Complimentary.
American Agriculturist......................	Subscription.
American Chemical Journal..................	"
American Chemical Society, Journal..........	"
American Cultivator.........................	Complimentary.
American Entomological Society, Transactions.	Subscription.
American Fancier...........................	"
American Fertilizer.........................	"
American Florist............................	"
American Gardening.........................	"
American Grange Bulletin....................	Complimentary.
American Grocer............................	"
American Journal of Physiology..............	Subscription.
American Monthly Microscopical Journal......	"
American Naturalist	"
American Philosophical Society, Proceedings..	Complimentary.
American Stock Keeper......................	"
Analyst	Subscription.
Annales Agronomiques......................	Subscription.
Annales de l'Institut Pasteur................	"
Annals and Magazine of Natural History......	"

Annals of Botany	Subscription.
Archiv der gesammte Physiologie (Pflueger)	"
Archiv fuer Hygiene	"
Association Belge des Chimistes, Bulletin	Complimentary.
Baltimore Weekly Sun	"
Beet Sugar Gazette	"
Berichte der deutschen botanischen Gesellschaft	Subscription.
Berichte der deutschen chemischen Gesellschaft	"
Boletin do Instituto Agronomico do Estada de Sao Paulo	Complimentary.
Boletin de Agricultura Tropical	"
Boston Society of Natural History, Proceedings.	Subscription.
Botanical Department, Jamaica, Bulletin	Complimentary.
Botanical Gazette	Subscription.
Botanische Zeitung	"
Botanisches Centralblatt	"
Botaniste, Le	"
Breeders' Gazette	"
Buffalo Society of Natural Sciences, Bulletin	Complimentary.
Canadian Entomologist	Subscription.
Canadian Horticulturist	Complimentary.
Centralblatt fuer Agrikultur-Chemie	Subscription.
Centralblatt fuer Bakteriologie und Parasitenkunde	"
Chemical News	"
Chemical Society, Journal	"
Chemiker Zeitung	"
Chemisches Centralblatt	"
Chicago Daily Drovers' Journal	Complimentary.
Chicago Dairy Produce	"
Cincinnati Society of Natural History, Journal.	"
Columbus Horticultural Society, Journal	Complimentary.
Commercial Poultry	"

Country Gentlemen	Subscription.
Country World	Complimentary.
Dairy and Creamery	"
Detroit Free Press	"
Edwards' Fruit-Grower and Farmer	"
Elgin Dairy Report	"
Elisha Mitchell Scientific Society, Journal	"
English Catalogue of Books	"
Entomological News	Subscription.
Entomological Society of Washington, Proceedings	"
Entomologische Zeitschrift	"
Entomologist	"
Entomologists' Record	"
Fanciers' Review	Complimentary.
Farm and Fireside	"
Farm and Home	"
Farm Journal	"
Farm News	"
Farm Poultry Semi-Monthly	"
Farm, Stock and Home	"
Farmers' Advocate	"
Farmers' Call	"
Farmers' Guide	"
Farmers' Tribune	"
Farmers' Voice	"
Feather	Subscription.
Feathered World	"
Florists' Exchange	"
Flour and Feed	Complimentary.
Fuehling's Landwirtschaftliche Zeitung	Subscription.
Garden	"
Gardeners' Chronicle	"
Gardening	"
Geneva Gazette	Complimentary.

Gleanings in Bee Culture....................	Complimentary.
Golden Egg	"
Green's Fruit Grower......................	"
Hedwigia	Subscription.
Herd Register	Complimentary.
Hoard's Dairyman	"
Holstein-Friesian Register	"
Homestead	"
Horticultural Visitor	"
Indiana Farmer............................	"
Industrie Laitiere	"
Insect World	"
Irrigation Age	"
Ithaca Democrat	"
Jahresbericht der Agrikultur-Chemie..........	Subscription.
Jahresbericht der Nahrungs und Genussmittel.	"
Jersey Bulletin............................	Complimentary.
Journal d'Agriculture Pratique...............	Subscription.
Journal of Applied Microscopy...............	"
Journal de Botanique.......................	"
Journal of the Department of Agriculture of Western Australia	Complimentary.
Journal of Experimental Medicine............	Subscription.
Journal fuer Landwirtschaft.................	"
Journal of Physiology......................	"
Just's Botanischer Jahresbericht.............	"
Landwirtschaftlicher Jahrbuch	"
Landwirtschaftlichen Versuchs-Stationen	"
Louisiana Planter	Complimentary.
Meehan's Monthly	Subscription.
Milch Zeitung	"
Mirror and Farmer.........................	Complimentary.
Monthly Weather Review....................	"
National Nurseryman	"
National Farmer and Stock Grower...........	"

National Stockman and Farmer..............	Complimentary.
Naturae Novitates	"
Naturaliste	Subscription.
Naturaliste Canadienne	"
Nature	"
Nebraska Farmer	Complimentary.
New England Farmer.........................	"
New York Academy of Science, Annals and Transactions	Subscription.
New York Botanical Garden, Bulletin.........	Complimentary.
New York Entomological Society, Journal.....	Subscription.
New York Farmer............................	Complimentary.
New York State Granger.....................	"
New York Tribune Farmer...................	"
North American Horticulturist...............	"
Northwest Horticulturist	"
Northwest Pacific Farmer...................	"
Oesterreichische Chemiker Zeitung...........	Subscription.
Ohio Farmer	Complimentary.
Ohio Poultry Journal..........................	Subscription.
Operative Miller	Complimentary.
Pacific Coast Dairyman......................	"
Pacific Coast Fanciers' Monthly..............	Subscription.
Pacific Rural Press..........................	"
Pomona Herald	Complimentary.
Popular Agriculturist	"
Poultry Herald	Subscription.
Poultry Keeper	Complimentary.
Poultry Industry	"
Poultry Monthly	"
Poultry Star	"
Practical Farmer..............................	"
Practical Fruit-Grower	"
Progres Agricole et Viticole..................	Subscription.
Psyche	"

Public Ledger, Philadelphia	Complimentary.
Queensland Agricultural Journal	"
Revue Generale de Botanique	Subscription.
Revue Horticole	"
Revue Mycologique	"
Royal Agricultural Society, Journal	"
Rural New Yorker	"
Salt Lake Herald	Complimentary.
St. Louis Academy of Science, Transactions	"
Sanitary Inspector	"
Science	Subscription.
Society of Chemical Industry Journal	"
Societe Entomologique de France, Bulletin	Complimentary.
Societe Mycologique de France, Bulletin	Subscription.
Southern Planter	Complimentary.
Southern Farm Magazine	"
Southwestern Farmer and American Horticulturist	"
Station, Farm and Dairy	"
Stazione Sperimentale Agrarie Italiane	"
Strawberry Specialist	"
Suffolk Bulletin	"
Sugar Beet	"
Texas Stockman and Farmer	"
Torrey Botanical Club, Bulletins and Memoirs	Subscription.
Up-to-Date Farming and Gardening	Complimentary.
Utica Semi-Weekly Press	"
Wallace's Farmer	"
Watkins Review	"
West Virginia Farm Review	"
Western Fruit-Grower	"
Western Plowman	"
Wiener Illustrierte Garten-Zeitung	Subscription.
Woman's Home Companion	Complimentary.
Zeitschrift fuer Analytische Chemie	Subscription.

Zeitschrift fuer Biologie	Subscription.
Zeitschrift fuer Entomologie.................	Complimentary.
Zeitschrift fuer Fleisch und Milch Hygiene.....	Subscription.
Zeitschrift fuer Pflanzenkrankheiten..........	"
Zeitschrift fuer Physiologische Chemie.......	"
Zeitschrift fuer Untersuchung der Nahrungs und Genuss-Mittel	"
Zoologischer Anzeiger	"
Zoological Record	"

METEOROLOGICAL RECORD.

PRECIPITATION BY MONTHS SINCE 1882.

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	In.	In.	In.	In.	In.	In.	In	In.	In.	In.	In.	In.	In.
1882	....	....	...	...	....	3.69	2.42	2.37	1.25	0.62	1.22	0.55	.....
1883	0.48	1.44	0.88	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.51	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.49	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.61	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.39	3.48	1.24	27.87
1887	0.18	2.17	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	3.88	0.99+	4.02	2.73	3.47	2.02	1.24+	27.48
1889	2.99+	0.25	0.66+	3.28	1.21	7.47	4.57	1.98	2.59	3.32	3.44	1.62	32.28
1890	2.16	1.45	2.16	2.20	5.49	5.26	1.07	4.31	5.81	4.51	2.40	....	36.88
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	3.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	2.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	3.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.64	3.59	0.43	0.47	29.36
1895	0.96	....	0.29	1.33	2.88	....	....	2.66	0.94	0.72	2.31	2.49	.....
1896	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.61	0.21	2.12	1.90	2.19	3.16	5.28	1.27	2.36	0.73	2.53	1.39	23.73
1898	1.74	0.83	1.54	2.03	1.90	2.39	1.32	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35
1900	1.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	3.65	6.13	0.78	27.73
1901	0.72	....	2.19	4.43	8.80	2.07	8.97	5.62	2.46	1.35	2.09	3.37	32.07

WIND RECORD FOR 1901.

DATE.	JANUARY.				FEBRUARY.				MARCH.				APRIL.			
	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.
1	2	......	......	18	......	......	4	20	......	......	16	8	......	......	......	24
2	2	......	......	16	......	......	......	15	6	......	......	8	5	13	......	6
3	4	2	12	......	......	12	3	2	1	12	4	......	20	4	......	......
4	......	......	9	12	......	7	5	12	......	......	16	8	2	......	......	22
5	......	......	......	18	......	......	......	24	......	......	......	24	1	......	......	15
6	......	......	......	11	......	......	......	24	......	......	8	16	7	12	......	2
7	......	......	4	13	2	......	......	21	......	......	8	11	3	......	......	21
8	......	......	6	10	6	......	......	12	......	3	17	......	......	......	......	24
9	3	......	......	9	......	11	1	9	7	......	6	7	......	......	......	24
10	......	9	9	......	......	......	......	21	4	12	......	......	......	......	......	24
11	......	......	......	19	......	......	1	13	......	12	......	12	2	......	......	22
12	......	......	......	21	2	......	......	21	......	......	......	23	5	......	......	12
13	......	......	6	1	3	......	......	21	......	15	......	7	......	6	6	3
14	......	......	12	7	......	......	......	24	......	3	8	......	......	6	4	......
15	2	......	13	......	......	......	......	24	......	......	......	17	3	3	......	6
16	......	......	9	12	......	......	3	16	......	......	1	23	5	......	1	15
17	......	......	......	24	......	......	......	17	......	......	11	8	......	19	......	......
18	5	......	......	17	2	4	......	7	2	4	7	8	......	14	7	3
19	4	......	......	19	......	......	......	24	18	6	......	......	1	......	......	23
20	......	......	15	6	......	......	......	24	......	23	......	1	21	......	......	......
21	......	......	12	11	......	......	2	16	......	3	6	13	16	8	......	......
22	12	......	......	......	......	......	2	16	......	......	12	11	2	14	1	......
23	......	7	12	......	......	......	12	5	......	14	5	......	3	......	3	......
24	......	3	16	......	......	......	6	9	......	17	3	......	8	......	......	8
25	4	......	......	17	......	......	17	2	......	22	......	......	19	......	......	5
26	1	......	......	23	......	......	2	22	2	11	7	4	6	......	......	17
27	......	......	......	24	......	......	......	24	......	......	......	24	......	7	2	5
28	......	......	......	21	......	......	......	22	......	......	......	24	9	1	......	......
29	......	......	......	20	......	......	......	......	......	......	......	24	2	......	7	9
30	......	6	3	4	......	......	......	......	......	......	......	21	......	......	9	13
31	......	......	......	15	......	......	......	......	......	......	......	21	......	......	......	......
Total hours of movement	39	27	13[illegible]	371	15	31	58	467	40	157	135	329	143	107	40	303
Per cent. of time in each direction	6.8	4.[illegible]	21.0	64.5	2.6	5.9	10.1	81.4	6.0	23.8	20.4	49.8	24.1	18.0	6.8	51.1

WIND RECORD FOR 1901—(*Continued*).

DATE.	May.				June.				July.				August.			
	Northerly, N. E. to N. W.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. E. to N. W.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. E. to N. W.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. E. to N. W.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.
1	13	......	5	6	......	6	10	6	......	......	7	7	......	......	1	21
2	2	3	9	10	......	3	9	7	......	......	18	6	1	......	10	5
3	3	......	......	21	......	......	......	24	5	......	2	10	......	3	2	13
4	......	......	......	24	......	......	......	17	1	8	4	6	......	......	......	24
5	4	......	......	18	......	10	6	6	5	1	......	11	8	......	......	3
6	5	12	......	......	1	......	7	10	......	......	5	14	6	12	......	......
7	......	10	10	......	......	......	3	19	......	......	14	10	1	......	8	10
8	......	12	2	......	......	......	......	24	......	......	5	14	......	2	14	7
9	......	19	......	......	......	......	......	24	......	......	......	24	2	8	1	8
10	......	18	......	......	4	......	......	16	......	......	22	2	......	4	15	5
11	......	3	1	16	5	3	6	......	1	......	8	15	......	......	1	15
12	......	2	18	4	8	......	......	9	7	2	......	11	......	......	......	......
13	......	......	10	14	2	8	6	2	......	14	......	1	......	8	1	1
14	3	......	6	9	1	......	1	9	......	9	6	......	......	14	5	......
15	......	......	......	16	18	......	......	......	......	9	7	......	......	11	5	......
16	2	4	......	6	5	8	......	......	......	2	2	5	1	......	2	17
17	......	......	2	13	2	11	3	......	......	1	5	9	......	......	......	2
18	7	......	1	9	......	......	24	......	......	......	12	8	9	6	......	......
19	5	11	2	......	1	6	12	......	5	......	......	12	6	16	......	......
20	2	6	......	......	......	......	9	8	......	3	7	12	1	10	......	2
21	......	16	......	......	......	8	......	2	......	......	9	15	......	5	......	......
22	......	18	1	2	4	7	6	......	1	......	......	16	......	8	9	4
23	......	......	2	18	......	......	7	17	6	......	......	11	......	......	19	4
24	......	......	2	18	......	......	......	20	4	......	5	10	5	......	......	7
25	7	5	......	12	2	4	5	2	10	......	......	9	8	......	......	5
26	......	19	......	......	4	6	......	4	5	9	......	......	......	2	3	1
27	7	2	......	2	......	......	3	17	2	8	12	......	1	7	......	......
28	3	......	......	19	......	......	8	16	4	3	9	7	......	5	10	......
29	......	6	2	3	......	......	13	9	......	8	8	4	......	1	21	......
30	......	2	4	13	......	......	9	15	......	......	9	15	......	2	12	3
31	......	......	12	7	......	......	......	......	......	......	2	17	5	......	1	2
Total hours of movement	63	168	89	260	57	80	147	283	56	72	178	281	51	121	140	159
Per cent. of time in each direction	10.9	29.0	15.3	44.8	10.1	14.1	25.9	49.9	9.5	12.3	30.3	47.9	11.3	26.0	29.4	33.3

Wind Record for 1901—(*Concluded*).

Date.	September.				October.				November.				December.			
	Northerly, N. E. to N. W.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. E. to N. W.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. E. to N. W.	Easterly, N. E. to S. E.	Southerly, S E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. E. to N. W.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.
1	7	......	......	......	......	1	23	......	......	......	9	15	......	......	24	......
2	4	......	......	3	......	......	10	12	......	......	......	14	......	......	10	14
3	......	......	......	11	......	......	......	21	......	16	4	1	16	......	......	8
4	......	......	......	19	......	......	5	19	......	4	5	12	......	......	......	24
5	......	......	3	6	......	......	18	5	......	......	8	14	2	......	......	15
6	2	......	......	2	......	......	1	21	......	......	......	21	1	3	4	3
7	4	......	......	5	......	3	7	......	......	2	14	7	......	18	6	......
8	6	......	3	14	......	3	16	......	......	......	2	15	......	9	7	......
9	......	......	......	12	......	2	21	......	......	......	6	16	......	6	11	2
10	......	9	11	1	......	8	6	......	......	......	......	22	......	......	6	17
11	......	......	10	8	......	5	8	......	......	11	3	7	......	......	4	10
12	......	1	8	12	......	11	10	......	......	3	......	21	......	2	5	1
13	......	......	3	17	......	3	7	9	......	......	......	24	......	7	17	......
14	......	7	1	5	3	......	2	11	......	......	......	24	......	1	11	10
15	......	4	19	1	......	......	15	......	......	......	10	14	......	......	......	24
16	......	......	13	4	......	......	10	4	......	......	15	9	......	......	......	12
17	......	......	6	8	......	......	......	24	......	......	4	20	......	5	2	1
18	......	......	5	9	......	......	12	12	......	......	......	21	......	......	11	3
19	2	......	......	14	......	......	12	12	......	......	6	18	......	......	8	9
20	1	5	9	......	2	......	......	13	......	......	10	5	......	......	7	11
21	......	......	7	8	......	......	7	11	......	......	13	6	......	......	7	16
22	......	2	22	......	......	......	6	18	2	......	10	1	......	......	24	......
23	......	11	13	......	......	......	......	24	11	4	......	......	......	2	21	......
24	14	......	6	4	1	......	......	21	24	......	......	......	......	......	1	12
25	13	......	......	......	......	......	......	14	1	......	......	23	2	3	5	6
26	1	12	3	......	......	......	12	3	......	......	......	24	......	1	12	7
27	......	13	10	......	6	......	3	10	2	......	......	22	......	......	......	19
28	......	5	17	......	4	1	......	......	......	......	......	24	......	2	14	1
29	......	2	18	4	......	22	1	......	3	......	12	9	1	5	1	14
30	......	......	10	10	......	20	4	......	4	......	3	5	9	......	1	14
31	......	......	......	......	......	12	10	......	......	......	......	......	......	......	5	19
Total hours of movement	54	71	197	177	16	94	226	264	47	43	134	414	31	64	224	272
Per cent. of time in each direction	10.8	14.2	39.5	35.5	2.6	15.7	37.7	44.0	7.4	6.7	21.0	64.9	5.3	10.8	37.9	46 0

SUMMARY OF DIRECTION OF WIND FOR 1901.

	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Total.
	Hours.	Hours.	Hours.	Hours.	Hours.
January	39	27	138	371	575
February	15	34	58	467	574
March	40	157	135	329	661
April	143	107	40	303	593
May	63	168	89	260	580
June	57	80	147	283	567
July	56	72	178	281	587
August	54	124	140	159	477
September	54	71	197	177	499
October	16	94	226	264	600
November	47	43	134	414	638
December	31	64	224	272	591
Total hours of movement	615	1,041	1,706	3,580	6,942
Per cent. of time in each direction	8.9	15.0	24.6	51.6	....

READINGS OF THE STANDARD AIR THERMOMETER.

DATE.	January.			February.			March.			April.			May.			June.		
	7 a. m.	12 m.	5 p. m.	7 a. m.	12 m.	5 p. m.	7 a. m.	12 m.	5 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.
1	22	24	22.5	16	23	17	16	33	41	34	41	43	46	49	56	54	55.5	58
2	6	25	19	16	23	19	34	23	19.5	36	45	48	52	73	63	48	58.5	55
3	2	14	9	12	27	29	10	29	35	33	33	33	43	48	53	52	60	63
4	18	33	29	32	34	21	32	40	39	33	37	35	46	58	59	61	70	74.5
5	9	20	18	17	17	16	17	20	17	35	41	41	54.6	66	69	59	78	80
6	12	25	25	12	16	13	0	9	10	37.5	42	43	54	65.5	66	67	84	80
7	33	35.5	31	9	19	16	9	30	33	35	42	41	55	72	71	61	63	62
8	26	33	38	10	18	17	30	35.5	39	35	36	35	67	69	71	48.5	53	51.5
9	37	33	31	11	11	13	39	34	32	33	37	39	56	64	58	52	61	61
10	32	35.5	38	11	18	17	28	34	36	35	41	46	57	64	62	55	70	73
11	36	35.5	32	20	30	25	38	38	33	35	43.5	45	58.5	65	71	56	65	74
12	35	31	27	21	22	18	29	31	31	38	54	51	54.5	63	52	66	79	78
13	27	29	29	4	10	8	23.5	29	28	40	57	57	45	56	56	70	84	83
14	30	34	35	7	13	15	34	39	38	44	53	55	48	58.5	52	68	81	79
15	34	38.5	37	18	23	25	32	32	27	47	57	51	47.5	61	61	60	72	70
16	39	46	39	17	33.5	30	21	29	27	43	60.5	57	49	65.5	67	65	74	70
17	30	28	27	19	31	28	24	34	35	44	60	61	56	68	61	63	74	75
18	9	7	6	22	31	29	30	48	52	48.5	55	53	54	66	57	62.5	64	62
19	1.5	2	0	25	29	24	22	28.5	29	31	35	35	53	59	54	66	67	73
20	6	26	36	19	21	18	34	40	42	35	38	39	51	59	57.5	65	67.5	71
21	41	43	41	8	18	17	32	35	34	44.5	59.5	56	52	61	74	63	76	79
22	16	19	18	14	21	16.5	30	31	30	50	61	57	61	67	61	73	81	78.5
23	20	33	34	5	19	13	28	45	53	51	55	54	64	71	76	76	79	72
24	32	34	36	3	18	18	42	54	54	49	57	49	62	60	51	66	80	80
25	30	30	28	25	28	34	44	56	53	48	53	59	45	48	52	70	83	84
26	19	21	19	21	27	23	50	49	42	48	54	57	49	53	51.5	77	86.5	87
27	22	25	25	11	21	20	35	36	35	48	61.5	66	52	56	55	80	90	93
28	23.5	23	19	11.5	21	21	21	24	26.5	54	70	70	47.5	48	51	82	93.5	84
29	15	21	20	......	......	......	26	30	34	53	75	71	51	63	57	79	93	88
30	19	23	23	......	......	......	27	35.5	37	58	69	63	52	54	56	76	86	87
31	19	23	18	......	......	......	30	37	39	......	......	......	57	62	62	......	......	......
Average	22.6	27.4	26.1	14.9	22.2	20	23	31.5	34.9	42	50.9	50.3	52.6	61.2	60.4	64.7	74.4	71.3

READINGS OF STANDARD AIR THERMOMETERS—(*Concluded*).

DATE.	JULY.			AUGUST.			SEPTEMBER.			OCTOBER.			NOVEMBER.			DECEMBER.		
	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	5 p. m.	7 a. m.	12 m.	5 p. m.	7 a. m.	12 m.	5 p. m.
1	81	90	89	66	73	73	63	70.5	69	49	71	68	48	60	54	29	45	45
2	84	89	91	64	78	76	61	74	71	60	51	56	43	48	42	43	41	33
3	78	86	82	68.5	76.5	75	65	80	80	45	54.5	47	32	53	51	24	23	21
4	71	87	75	67	74	75	69	82	80	41	54.5	47.5	39	45	33	17	17	15
5	69	77.5	74	65	74	72	69	83	81	37	52	52	32	35	35	16	20	16
6	78	85	83	63	73	62	68	84	81.5	41	47.5	46	33	41	36	6	24	19
7	67	79	73	61.5	61	73	68	85	82.5	36	55	57	32	46	50	18	28	30
8	63	72	69	66.5	77	81	58	60.5	60	43	64	63.5	40	41	37	32	35	36
9	64	74	76	63.5	73	71	55	66	63	50	63	61	39	46	41	42	38	36
10	67.5	83	87	74	72	78	59	61	66	57	69	68	28	34	29	36.5	35	33
11	70	66	73	63	71	71.5	63	71	68	52	70	68	32	39	44	34	37	36
12	66	76.5	77	61	71	73	61	70	74	58	69	65	56	44	38	31	41	38
13	71	82	84	66	76	79	64	68	69	64	60	61	29	32	33	42	49	51
14	74.5	84.5	87	67	83	79	59	71	70	49	61	54	30	33	30	57	62	50
15	79	88.5	90	69	71	70	65	73	66	45	57	55	27	34	34	21	17.5	12.5
16	81	75	79	66	76	74	65	74	69	49	55	46.5	33	36.5	33.5	10	17	9
17	77	87	91	63	75	73.5	55	56	60	41	47	43.5	33	34.5	33	7	11	12
18	81	89	87	65	77	80	49	61	55	34	43	41	31	34	33	8	20	17
19	76	76	72	71	81	79	45	54.5	52	49	59	48	27	28	26	7	15	13
20	62.5	83	86	72	84	73	43	57	55	35.5	46	45	19	33	29	7	21	13
21	81	92	90	70	85	82	51	63	61	39	57	56	31	39	37	10	17	11
22	80	85	86	74	87.5	74	53	72	67	54	62	58	29	42	40	9	21	24
23	71	85.5	85.5	75	84.5	71	56	76	71	60	71	65	29	31.5	34	32	36.5	35
24	77	89	87	69	70	71	59	75	60	41	42	40	31	34	35	34	35	35
25	62	66.5	67	65	72	73	44	58	51	33	45	44	33	33	32	22	38.5	34
26	61	71	73	66	79	75	45	63	61	34	57	61.5	22	19	19	28	31.5	34
27	65	75.5	79	67	79	78	53	69	65	48	52	47	19	20	18	31	35.5	34
28	72	91	89	69	81	79	56	67	66	29	51	46.5	14	18	19	27	36	35
29	71	82	80	66	81	78	65	76	73	43	58	55	29	31	35	33	35	33.5
30	76	87.5	86	69	73	73	63	60	55	46	62	61	27	30	29	31	31	25
31	71	81	73	65	73	66.5	......	......	......	48	63	65	......	......	......	30	33.5	23.5
Average	72.6	81.8	81.3	67	76.3	74.5	58.4	69.3	66.7	45.5	57.2	54.6	31.7	36.5	34.6	25.3	30.6	27.7

SUMMARY OF MAXIMUM, MINIMUM AND STANDARD AIR THERMOMETERS FOR 1901.

	Maximum.	Minimum.	Standard.		
			7 a. m.	12 m.	Sunset.
	Average.	Average.	Average.	Average.	Average.
January	33.6	18.5	22.6	27.4	26.1
February	25.9	11.1	14.9	22.2	20.0
March	40.6	23.7	28.0	34.5	31.9
April	56.0	37.1	42.0	50.9	50.3
May	67.0	46.8	52.6	61.2	60.4
June	80.5	57.4	64.7	74.4	74.3
July	88.2	65.1	72 6	81.8	81.3
August	80.9	61.1	67.0	76.3	74.5
September	75.0	53.0	58.4	69.3	66.7
October	62.1	40.7	45.5	57.2	54.6
November	41.0	27.7	31.7	36.5	34.6
December	31.9	20.6	25.3	30.6	27.7

READING OF MAXIMUM AND MINIMUM THERMOMETERS.

1901.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	5 p. m. Max.	5 p. m. Min.	5 p. m. Max.	5 p. m. Min.	5 p. m. Max.	5 p. m. Min.	6 p. m. Max.	6 p. m. Min.	6 p. m. Max.	6 p. m. Min.	6 p. m. Max.	6 p. m. Min.	6 p. m. Max.	6 p. m. Min.	6 p. m. Max.	6 p. m. Min.	6 p. m. Max.	6 p. m. Min.	5 p. m. Max.	5 p. m. Min.	5 p. m. Max.	5 p. m. Min.	5 p. m. Max.	5 p. m. Min.
1........	36.5	20	23	12	41	7.5	46	32	64	44	63	50	97.5	67	75	59	75	61	73	43	65	47	48	21.5
2........	25	4.5	25.5	7.5	42	19	50	29	75	41	67	42	95	75	83	52.5	76	61.5	68	50	53.5	39	49	33
3........	19	1	29	6	36	2.5	48	32	64	39.5	65	48.5	91	73	81	63	84	58	57	39	57	28	34	20
4........	34	4	34.5	20	41.5	30	37	32	61	39	75.5	48	91 5	62	80	63	83.5	62	55	37	52	32.5	21	15
5........	23	7	23	15	42	16	45	34	72.5	49	84.5	49	80	66	78.5	52	88	60.5	57	33.5	36	31	22	15
6........	27	11	17	12	18	—1	44	35	70	42.5	87.5	62	86	68.5	75	56	89	61	53	40	44	32	29	4
7........	36	21	25	8	35	6	45	33.5	78	44	80	57	84	63	73.5	57	88.5	62	62	32.5	51	26.5	31	13
8........	39	23	26	9	40	28	44	34	75	51	62.5	47	74.5	59.5	84	59.5	84	53.5	69.5	38	51	37	36	28
9........	47	30	18	0	42	30	39.5	32	72	53	66	44	80	57	82	52.5	72	46	64	47	47	30.5	43.5	35
10........	39	25	20	10	37	27	48	35	69	54	75	48	89	59	78	66	69	54	74	54	42	27	47	32
11........	40	32	34	3.5	38	33	49	31	75.5	56	76	52	87	65	79.5	57	76	60	74	49	44	21	40	31
12........	37	27	26	16	35	27	55	28	73	48	83	60	81	56	75.5	57.5	80	60	73	55	58	37	44	30
13........	31	24.5	18	3	33	20	63	32	59	38.5	87	56	86.5	58	82	55	75	59.5	67	57	39.5	28	53	32
14........	37	31	16	5.5	43	27	60	40	60	42	86.5	63.5	89.5	65.5	85	59	76.5	56	62	47	35	23	62	48
15........	47	30	27	14.5	40	26	59	10	65	38	79	57	93	68	79	66	75	62	60	42	35	26	51	12
16........	48	34	36	16.5	29	19.5	62	38	70	36	79.5	57	90.5	72	81	64	77	58	55.5	42	37	32	20.5	9
17........	40.5	27	33	18	35	19	66	34	70	46	79.5	48	94	73	76	59	70	53	50	40	35	31.5	12	5
18........	30	5	32	20	55	26	63.5	46	68	51	76	59	93	70	83.5	62	63	44.5	45	32	35.5	29	24.5	—1
19........	12	—1	31	23	32.5	20	55	33	62	47	77.5	55	88	66	84	63	60	41.5	60.5	36	33	24.5	17.5	6
20........	39	—2	25	17	42	27	40	33	62	49.5	74.5	59	91	54.5	88	69.5	61.5	37	49.5	31	35.5	17	24.5	4.5
21........	45	34	21	7	46.5	31	60	38	74.5	46	80.5	60	95.5	72	88.5	66.5	67.5	45	61	33	39	22	18	4.5
22........	43	15	22.5	11	35.5	27	64	47	69.5	58.5	87	64.5	90	73	90	70	76	45.5	64	42.5	46	28	26	0
23........	36.5	12	22	4	55	22	58	44	78	56	82	68	89	64	86	67	80	51.5	72	45	41	28	38	23
24........	38	29	21	—2.5	67	38	59.5	44	76	50	85	60	93	63	75	67	76	53	66	39	36.5	30	36	29.5
25........	33	27	35.5	16	58	39	61	47	53	43	87	60	89	60	78	61	62	37	50	31.5	36	31	38.5	31
26........	29	17	35	19	54	41	63	43	55	48	92	66	76	56	80	57	68	36	69	30	33	18	35	24
27........	27	18.5	24	10.5	43	33	68.5	36	56	49.5	95.5	70	81	56	84	58.5	74	49	62	45	23	17	33	29.5
28........	26	19	24	9	37	20	75	40	57	45	95.5	77	94	65.5	84	63	69	48	55	28	20	13	37	25
29........	24.5	14	....	....	35.5	24	78	42	64	47	95.5	69	89	72	85	62	79	60	59	34	35	13.5	36	31
30........	24	18	....	....	39	23.5	75	49	58	50.5	89	65	91	72	80	66	74	55	63	45	36	25	35	25
31........	25	16.5	....	....	41	26	....	....	69	49	....	....	86	67	74	64	....	....	70	46	....	....	35	21.5
Average.	33.6	18.5	25.9	11.1	40 6	23.7	56	37.1	67	46.8	80.5	57.4	88.2	65.1	80.9	61.1	75	53	62.1	40.7	41	27.7	34.9	20.6

AVERAGE MONTHLY TEMPERATURE SINCE 1882.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1883	17.4	22.3	23.6	43.3	52.0	66.6	67.4	65.6	56.3	46.6	39.1	27.5
1884	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	36.5	27.2
1885	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.0	58.3	49.2	39.3	27.8
1886	19.6	22.9	30.2	48.1	55.7	64.0	68.0	67.5	61.8	49.6	36.8	22.2
1887	20.2	23.2	26.3	41.1	62.5	65.7	75.6	66.5	57.7	47.0	37.6	27.6
1888	16.4	22.8	24.6	40.8	54.3	66.5	66.8	68.0	62.2	43.9	39.4	29.3
1889	29.1	18.1	33.9	45.1	58.4	65.3	70.2	66.0	60.5	44.0	40.3	35.2
1890	31.2	30.9	28.3	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4
1891	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.3	38.4	35.5
1892	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.3	50.0	35.9	25.2
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5
1894	29.7	20.6	38.9	44.1	55.5	67.8	74.2	66.8	64.9	52.7	36.0	31.5
1895	21.8	16.9	26.9	44.4	59.0	....	....	71.2	61.7	45.4	39.6	31.4
1896	22.4	24.1	21.4	49.3	62.0	65.9	71.4	70.0	60.2	56.5	42.9	27.1
1897	23.2	26.1	33.8	45.0	55.4	62.3	73.6	67.6	62.3	52.6	39.7	29.2
1898	26.2	26.8	....	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9
1899	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.4	38.9	30.0
1900	26.0	22.6	23.6	43.5	56.7	68.4	72.6	74.1	66.1	57.9	41.1	28.7
1901	26.1	18.5	32.2	46.5	56.9	68.9	76.6	71.0	64.0	51.4	34.3	27.7

INDEX.

INDEX.

A.

B.

C.

D.

E.

H.

I.

J.